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G-000-307 .24

HISTORY OF FMPC RADIONUCLIDE DISCHARGES - (USED AS A REFERENCE IN OU2 AND OU5 RI REPORTS)

11/01/85

NLCO-2039
NLO DOE
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NLCO-2039
Internal Special

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By

M. W. Boback, D. A. Fleming, T. A. Dugan,
R. W. Keys and R. B. Grant

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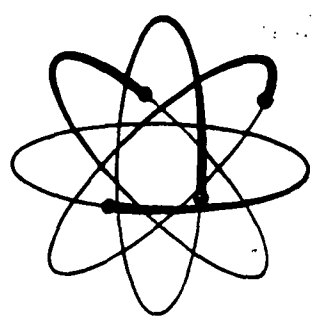

FEED MATERIALS PRODUCTION CENTER

NLO, Inc.
P. O. BOX 39158
CINCINNATI, OHIO 45239

PREPARED FOR THE
U.S. DEPARTMENT OF ENERGY
WEAPONS DIVISION OF OAK RIDGE OPERATIONS
UNDER CONTRACT DE-AC05-76OR01156

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NOTICE

6379

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Weapons Division of Oak Ridge Operations
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Approved:

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HISTORY OF FMPC RADIONUCLIDE DISCHARGES

INTRODUCTION

This report presents information on the discharge of radionuclides from the Feed Materials Production Center. Discharges to both air and water have occurred but airborne releases are emphasized because inhalation is the only potential exposure route for most offsite residents in the FMPC area. Industrial wastewater from the site enters the Great Miami River but there is no known downstream use of the river as a potable water supply.

Information in this report was compiled in response to a DOE request for a history of radionuclide discharges during the 34 years of FMPC operations from 1951 through 1984. DOE desired that best estimates be made when sampling data were not available to provide a complete history. This desire applied most directly to airborne uranium discharges because of the relative importance of the airborne pathway in regard to radiation doses to offsite population groups. Therefore, for those periods when stack emission data were not available, reasonable estimates were made. Most of these estimates were made by extrapolating from periods when emissions were measured or they were derived from measured production - discharge ratios applied to periods for which only production data were available.

SITE OPERATIONS

The FMPC is a uranium production facility owned by the U. S. Department of Energy and managed by NLO, Inc., under a prime contract. Production facilities occupy 136 acres in the center of the 1050-acre site. Cincinnati, Ohio, is located 16 miles to the southeast and the small communities of Fernald, Shandon, Okeana and Ross are located within several miles of the site. See Figure 1.

Uranium production has been the primary FMPC activity since the first operations began in October, 1951. Uranium isotopes, therefore, have been the principal radionuclides discharge in air and water. Lesser amounts of thorium were also produced on several occasions and small quantities of thorium were emitted.

Uranium received at the FMPC has been through one or more chemical separations at other sites. These separations remove most of the daughter products and ingrowth of new daughters is limited by the long half lives of several of those daughter isotopes. This was not the case when pitchblende ore and uranium concentrates (yellowcake) were processed in the FMPC refinery. In pitchblende, the entire decay chain is present and the concentrates contained daughter products which passed through the initial milling operation. The most significant daughter product present in both types of feed was radium-226.

High quality uranium compounds are introduced into the FMPC processes at several points. Impure starting materials are dissolved in nitric acid

and the uranium is extracted into an organic liquid and then back-extracted into dilute nitric acid to yield a solution of uranyl nitrate.

Evaporation and heating convert the nitrate solution to uranium trioxide (UO_3) powder. This compound is reduced to uranium dioxide (UO_2) with hydrogen and then converted to uranium tetrafluoride (UF_4) by reaction with anhydrous hydrogen fluoride. Uranium metal is produced by reacting UF_4 and magnesium metal in a refractory-lined reduction vessel. This primary uranium metal is then remelted with scrap uranium metal to yield a purified uranium ingot which is shipped offsite for extrusion. Enriched ingots are extruded into billets which are shipped directly from the extrusion plant to the DOE facility near Richland, Washington. Depleted ingots are extruded into long tubes which are returned to the FMPC for sectioning and machining to final dimensions. The finished sections, called "cores," are shipped to the DOE Savannah River site in South Carolina.

AIRBORNE DISCHARGES

Most uranium production operations involve the generation of dust, fume or reaction gasses. These operations are conducted in ventilated enclosures and the air is passed through dust collectors or scrubbers. The filtered or scrubbed air is exhausted to the atmosphere. Over ninety dust collectors have been used at the FMPC and currently fifty five are

in use. Since the mid-1950's, dust collector discharges have been determined through continuous stack sampling. Each stack has a sampling system which consists of a center-line probe, a pleated filter and a vacuum source. The vacuum is adjusted for isokinetic sampling. Filters are changed regularly and analyzed for uranium.

Stack sampling was originally undertaken to show there was a need for close attention to dust collector operations. Minor problems with sampling rates and sampler vacuum supply did not interfere with this objective but may have affected the accuracy of discharge estimates. These problems have received attention and no longer exist because of changes made over the years. Stack flow rates were determined for the initial adjustment of sampler vacuum but were not rechecked unless there was reason to suspect a significant flow rate change might have occurred. Vacuum lines were occasionally found disconnected or the vacuum pump turned off. In the brief uranium hexafluoride process in plant 7, the centerline probes were occasionally plugged. Some discharges, determined from the stack samplers, were not corroborated by other means. These discharges were, nevertheless, reported despite the lack of corroboration. The effect of this reporting is that discharges in some years would have been overestimated.

Table 1 contains the height and diameter of FMPC dust collector and scrubber stacks as well as the stack exhaust velocity. When originally installed, all stacks had rain caps as shown in Figure 2. There are

plans to remove all rain caps so that stack discharge conditions fit the capability of the EPA-mandated computer program for calculations required under National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations. Table 2 contains data on building dimensions and roof heights. Figures 3 and 4 show production building locations and other important site features.

Continuous air sampling is carried out at seven locations on the plant boundary. See Figure 3. Air is drawn at one cubic meter per minute through an 8-inch x 10-inch filter which is changed weekly. The filter and its dust load are dissolved in nitric acid and the resulting solution is analyzed for uranium and radioactivity. The remaining solution is held to provide a long-term composite for the determination of other radionuclides such as thorium isotopes and transuranics. Boundary air sampling results are reported in an annual Environmental Monitoring Report.(1)

Since 1981, commercial samplers have been used to measure radon at the plant boundary air sampling stations and two offsite locations. The devices are left in position for a calendar quarter and then returned to the manufacturer for readout. Results have been consistently well within the DOE standard for radon-222 in ambient air. Recent reports by the Ohio Department of Health and Monsanto Research Corporation show lower concentrations than determined by the commercial devices used by NLO.

The principal source of radon at the FMPC is a pair of concrete silos which contain the radium-bearing residue from the processing of pitchblende ore. An earth embankment surrounds both silos. Total residue weight in both silos is 19.4 million pounds. The estimated total quantity of radium-226 is 1652 curies. All openings in the top of the silos have been gasketed and are bolted shut. Additional silo information starts on page 20 of this report.

WASTEWATER DISCHARGES

Each of the individual production plants have sumps and equipment for the collection and initial treatment of process wastewater. Effluents from the plants are collected at a central facility, called the General Sump, for mixing and additional treatment, if needed. At the present time, the collected wastes are held in large tanks until the solids settle. The clear supernate is tested and discharged to the Great Miami River along with sewage plant effluent and water which collects in the storm sewer system. Settled solids are pumped to filters and after filtering the damp solids are drummed for offsite disposal at an approved facility.

Prior to the current practice of drumming wastewater solids for offsite disposal, the treated wastes were sent to onsite pits. The solids settled and the clear supernate flowed to a clearwell. The clear supernate was pumped from the clearwell to the discharge line leading to the Great Miami River. The first settling pit was clay lined; the second

was lined with clay plus a synthetic membrane. Neither pit is in active use. The first pit is covered with clean fill; the second pit remains open but receives only collected precipitation from an adjacent solid waste pit.

The FMPC production area is served by a storm sewer system which collects precipitation runoff and routes the flow to a storm sewer lift station. The station's two pumps transfer the water to the main wastewater discharge line which leads to the Great Miami River. If the flow exceeds the station pumping capacity, the excess overflows to the storm sewer outfall ditch, a natural drainage course which leads to Paddy's Run in the southwest corner of the site. Paddy's Run, an intermittant stream, meets the Great Miami River about 1.5 miles south of the FMPC.

An onsite tertiary treatment plant handles all sewage generated at the FMPC. The system consists of a primary settling basin, a sludge digestion tank, two trickling filters operated in series, a secondary settling basin and ultraviolet disinfection of the basin effluent.

Daily samples are collected of the individual major wastewater effluents: General Sump, pit clearwell, sewage treatment plant and storm sewer system. In addition, a continuous sample is collected from the discharge line after all streams mix together. Samples are analyzed for uranium, alpha and beta radioactivity and several nonradioactive chemicals. Since 1975, the discharge of wastewater has been governed by a permit issued

under the National Pollutant Discharge Elimination System administered by the U. S. Environmental Protection Agency and the Ohio EPA.

The discharge of radionuclides has always been within the limits set by the Department of Energy and its predecessor agencies.

Water samples are collected from the Great Miami River upstream and downstream of the FMPC discharge line. Samples are analyzed for uranium, radium, and several non-radioactive chemicals. Results are reported in the annual Environmental Monitoring Report and show consistently that downstream concentrations are well within federal and state water quality standards.(1)

GROUNDWATER

Action by the Illinoian and Wisconsinan ice sheets gave the FMPC area its basic geological features and provided conditions for a bountiful groundwater supply. Outwash from retreating glaciers filled in the wide valley of a large ancient river. Underlying the FMPC is about 50 feet of clay-rich till which may be a remnant of a large glacial moraine. Beneath the till is about 150 feet of sand and gravel which fills the buried valley of the preglacial river. The sand and gravel layer provides a steady potable water supply. In the FMPC area, the groundwater flows in a southerly direction and water which passes under the site is thought to enter the Great Miami River between New Baltimore and the mouth of Paddy's Run. See Figure 1.

Three production wells were installed on the FMPC site in 1952 and have been tested routinely since that time. A network of test wells has been installed over the years with the first wells placed around the waste storage area. During 1984, there were 12 onsite test wells and the three original production wells which were sampled on a routine basis.

Since 1981, the groundwater sampling program has been expanded to include 21 offsite wells. Wells in three offsite locations show above-background concentrations of uranium. One location is a residence where the water supply was used until 1984. The other two locations are small companies which use the wellwater for industrial purposes only. After the analysis by NLO and the Ohio Department of Health of samples from over 100 wells in the FMPC area, no other wells have been found to contain above-background uranium concentrations.

A year-long study by a consulting firm identified the likely source of uranium in the offsite wells.(2) In most of the site area, the clay-rich till minimizes the movement of surface water into the sand and gravel aquifer. This retarding cover thins out in the southern part of the site and water quickly percolates into the ground. The storm sewer outfall ditch which carries overflow from the FMPC storm sewer system was identified by the consulting firm as the primary pathway for uranium-bearing water to reach the upper layer of the aquifer. The southern reach of Paddy's Run was identified as a pathway of lesser importance.

DATA COMPILATION: AIR EMISSIONS

Although daughter products, fission products and transuranic nuclides have been emitted, most of the calculated potential dose from FMPC operations is due to uranium. Because of this fact, considerable effort was expended on the compilation of airborne uranium discharges for each dust collector stack on a calendar year basis. Results are reported in Tables 3 - 11.

Plant 1 operations began in December, 1953 and sampling of the plant 1 dust collector stacks began in September 1955. Because of the low production rate during initial operations, it is reasonable to assume that stack discharges in 1954 would not have exceeded the discharge estimated for 1955. Therefore, in Table 3, the same estimate (15.4 kg U) is given for 1955 and 1954. An estimate of 1 kg U was made for December, 1953.

The 1955 discharge of 15.4 kg U reported in Table 3 for plant 1 is the total measured from the start of sampling in September through December. No production records are available which would provide a basis for extrapolating the four-month measured loss to an estimate for the entire year. Therefore, the discharge measured in September-December is assumed to be the discharge for the entire year.

Operations in plant 2/3 (the FMPC refinery) began in December, 1953 and stack sampling began in July, 1955. The 1955 discharge of 156 kg U reported in Table 4 for plant 2/3 is the total measured from the start of

sampling in July through December. This amount (156 kg U) discharged over six months is greater than the annual discharge estimated by using the 1956 production-discharge ratio. In 1956, the refinery stack discharge was 0.0428 kg U for each metric ton of uranium product. In 1955, the refinery produced 3288 MTU; based on the 1956 production-discharge ratio, the 1955 discharge would have been 141 kg. Therefore, the larger amount (156 kg U) was considered as the total 1955 discharge.

Operations in plant 4 began in October, 1953. Stack sampling also began in 1953 although the specific dust collectors are not identified in the 1953 and 1954 reports. Because of the intermittent stack sampling in plant 4, 1953 and 1954 discharge estimates were based on annual tonnage rates which are known for both years (see Table 5). It was assumed that the sitewide discharge rate per MTU produced was the same in 1953 and 1954 as it was in 1955 which is the year with the greatest production-discharge ratio.

Plant 5 operations began in May, 1953 and stack sampling began in November, 1953. During 1954, stack sampling in plant 5 was limited to the month of January. Reports for both years do not identify the specific dust collectors. Because of the scarcity of data for both years, the discharge estimation was based on the production-discharge ratio for 1955. Plant 5 discharges are given in Table 6.

Operations in plant 6 began in July, 1952 and stack sampling began in August, 1955. The total discharge measured from August through December

was 22 kg. See Table 7. During 1956 and 1957 when the plant 6 production was considerably greater, the discharge was 27 kg and 35 kg, respectively. Therefore, a 1955 estimate based on the 1956 or 1957 production-discharge ratio would be less than 22 kg. For this reason, the estimate for the entire 1955 year was left at 22 kg and the same discharge was assumed for 1953 and 1954. One half of the 22 kg was assumed as the discharge for the six months of operation in 1952.

Plant 7 operations began in June, 1954 and ended May 28, 1956. Stack sampling began in September, 1955. From September through December 1955, the total discharge measured was 5873 kg, including one month when the discharge was 4102 kg. The discharge reports mention that the sampling lines were plugged with UF_4 but no adjustments could be made for the unknown time that the samplers were non-functioning. Because of a lack of production data for 1955, no extrapolation could be made for the entire year. An extrapolation could be made based on time; that is, if 5873 kg U was discharged in four months, the total for 12 months was (3) X (5873) or 17619 kg U. There is, however, no basis for assuming that production rates or the stack discharges were even throughout the year. In Table 8, the total for 1955 is rounded off at 6000 kg U.

The measured plant 7 discharge during five months of operation in 1956 was 1718 kg U or an average of 344 kg per month. It was assumed that the discharge rate during the startup months in 1954 was the same as the rate in 1956: 7 months at 344 kg/mo gives a total of 2408 kg as the estimated discharge for 1954.

Operations in plant 8 began in October, 1954 and stack sampling began in July, 1955. The total measured discharge in 1955 was 966 kg U, with 815 kg being measured in one month. Based on the production-discharge ratio in 1956, the estimated discharge for 1955 is 865 kg U. Therefore, the six-month measured quantity of 966 kg is shown in Table 9 as the estimate for the entire year.

Uranium production did not begin in plant 9 until 1957. Stack sampling for uranium began at the same time and all data in Table 10 are from measured discharges; no estimates were necessary.

Operations in the Pilot Plant began in October, 1951 and stack sampling began with June-through-August sampling in 1953. Three months of sampling was also conducted during 1954. Discharges during these periods were extrapolated for both years, using adjustments derived from the site-wide production-discharge ratios. The discharge in 1952 was assumed to be the same as the 1953 discharge. The discharge for three months of operation in 1951 was based on the annual estimates for 1952 and 1953. See Table 11.

Most FMPC dust collectors have handled several different enrichments and many have handled more than one uranium compound throughout an operating lifetime. Attempting to assign compounds and enrichments to each collector for each year that a discharge occurred would be difficult and inexact. A large part of the assigning would have to depend on the memories of a small group of operating personnel who worked in the

production operation since the early and mid 1950's. In some production plants, overall operations have changed little over the years. For example, UO_3 has been the major refinery product; the plant 4 process still begins with UO_3 and ends with the UF_4 product; in the plant 5 reduction area the major dusts are UF_4 and U_3O_8 (in MgF_2); U_3O_8 is the principal uranium dust produced in the plant 5 remelt area, plant 9 and plant 6. Various compounds have been handled in plant 1, plant 8 and the Pilot Plant.

A history is available of the average enrichment in dust collector discharges (See Table 12). The history is on a fiscal year basis and records are not available to convert it to a calendar year record for much of the period covered.

Three plant 1 dust collectors listed in Table 3 were not equipped with stack samplers through 1984: G2-2, G2-6014, G2-6015. Samplers were installed in 1985. In general, these dust collectors served operations that involved dusts with low uranium concentrations. Based on a review of operations and materials handled, it is not likely that discharges from each collector would have exceeded an average of 0.5 kg U per year. Collector G2-2 serves a station where magnesium fluoride slag is unloaded from drums or hoppers for milling. Uranium content of the slag is low, about 0.2% by weight. Collector G2-6014 serves an operation in which 55-gallon steel drums are cleaned with abrasive grit. Prior to this step, the drums are sent through a drum washer to receive a caustic solution wash and a water rinse. This step removes all but traces of

material from the drums and most of the dust collected in G2-6014 consists of rust, paint flakes and grit fragments. Collector G2-6015 also served the abrasive cleaning operation for many years. For the past few years, the collector has ventilated an operation for shredding copper motor windings which contain only traces of uranium.

Table 13 contains information about systems used to incinerate various types of FMPC wastes. The old oil burner and the graphite burner were simple fire boxes with short stacks. High temperatures and the variable exhaust velocity interfered with proper stack sampling of these units; therefore, discharge estimates are based on knowledge of the amount of material burned and available sampling data. Discharge estimates for the old solid waste incinerator are based on data from several stack emission tests. The last years of operation for these three units were: Oil burner, 1979; old solid waste incinerator, 1979, graphite burner, 1984. Estimates of uranium discharged from the new solid waste incinerator are based on compliance stack testing data; estimates for the new liquid organic incinerator are based on performance criteria and the concentration of uranium in the incinerator feed.

Plant 8, the recovery plant, has five wet scrubbers which receive the airborne discharges from furnace and kiln operations. These operations are generally used to prepare uranium residues for the FMPC refinery. Estimates of uranium discharges are made monthly for each unit by the NLO Materials Control & Accountability Department; the estimates are based on loss factors established by stack sampling. Discharge records have been

kept on a fiscal year basis and no records prior to 1980 are available for conversion to a calendar year basis. Data for individual scrubbers are not available prior to 1980; therefore, information in Table 14 is on a fiscal year basis and is the total uranium discharge for all plant 8 scrubbers.

Table 15 contains information on the concentration of other radionuclides in recent samples of scrubber solutions. Results are reported in microcuries of radionuclide per kilogram of uranium. For the purpose of this report, it can be assumed that the radionuclide-to-uranium ratio in the stack effluent is the same as in the scrubber solution. Information is not available on which ratio adjustments could be based for materials processed in earlier years.

Particle size information was obtained on bulk dust collector material and on air stream particulates from collector inlet and outlet ducts. A subcontractor team used an Andersen Mark III in-stack particle fractionating sampler to collect the airstream samples. Because of the low dust loading in outlet ducts, sampling periods of up to 80 hours were required. After sample collection, glass fiber filters from the fractionating sampler were weighed by the subcontractor and returned to the FMPC where they were dissolved for uranium analysis. Because of the small amount of material collected on many sampler stages, the quantity of uranium on each stage as determined by analysis for uranium is a more accurate figure than the weight of total material that might have been obtained from filter weighings. Following the analyses for total

uranium, solutions from all stages of each sample were composited for a determination of isotopic uranium composition.

Inlet and outlet duct samples were collected from 15 dust collectors and analyzed before this report was assembled. Results are given in Tables 16 - 30. As sampling access is arranged for other dust collectors, the subcontractor will obtain additional samples. However, since numerous operations are conducted on a campaign basis with down time between campaigns, it will require more than a year to sample all existing collectors.

Bulk samples have been collected from 21 other dust collectors and analyzed for particle size, percent uranium, and isotopic uranium composition. Results are given in Tables 31 - 51. Bulk samples have now been collected from 36 collectors. There are 62 collectors at the FMPC, six of which are not currently in use. Because of the campaign mode of operation and delays in operating some production processes, it is likely to require over a year before bulk material is obtained from all collectors.

As noted earlier, airborne emissions produce the only offsite exposure that most area residents would receive from FMPC operations. In those emissions, uranium is the principal radionuclide and produces most of the dose. Other radionuclides are present in low concentrations and are of lesser interest in determining historical doses. However, because of the low concentrations and resulting stack sampling difficulties, the only

analytical data available is from the analyses of annual boundary air sample composites. To provide a basis for estimating the emission of other radionuclides, all samples of dust collector bulk dust were analyzed for 14 other nuclides. Results for the 36 bulk samples collected thus far are given in Tables 52 - 87. These nuclides are uranium and thorium daughter products, transuranics and fission products. There is no cooboration that the concentration of trace nuclides during past years was identical to concentrations found in present samples of bulk dust.

On several occasions, thorium compounds and thorium metals were produced at the FMPC. These operations were served by dust collectors and scrubbers and occasional thorium discharges occurred. Table 88 lists all such releases.

DATA COMPILATION: WASTEWATER DISCHARGES

Radionuclides in wastewater do not contribute significantly to the population radiation dose because average concentrations are low and the Great Miami River is not used as a potable water supply. For example, an individual who consumed 1.2 liters per day from a point just below the FMPC effluent outfall during 1984 would have a 50-year committed dose equivalent of 0.073 mrem to the bone surface and 0.01 mrem effective dose equivalent. These doses are well below DOE standards.

While a record has been maintained of the discharge of uranium in wastewater, radionuclides at lesser concentrations have been less closely

monitored. Starting in 1969, however, estimates were made for other nuclides based on the analysis of several long-term composite samples each year.

A record of wastewater discharges is given in Tables 89 and 90. Table 89 is a fiscal year record of uranium discharges beginning in 1952. Table 90 is a calendar year record, starting in 1957, for several other radionuclides.

DATA COMPILATION: GROUNDWATER

Offsite wells that are routinely sampled are shown in Figure 5 and 1984 results are given in Table 91. Wells 12, 15 and 17 have above background uranium concentrations. Well 12 is at a private residence and the well water was used until April, 1985 when a new deep well was installed; water from the deep well contains only background uranium. Wells 15 and 17 are at small industrial sites. At the well 15 site, bottled drinking water has been in use for at least two years. At the well 17 site, bottled drinking water has been used since 1974.

The average uranium concentration found in these three offsite wells during 1984 was used to calculate the 50-year committed dose equivalents, assuming the wells were used as the sole source of drinking water. Maximum committed dose equivalents due to ingestion of water from well 12 are 66.5 mrem effective dose and 908.0 mrem to the bone endosteum. For well 15, the doses are 89.0 mrem and 1203.8 mrem; for well 17, the doses

are 14.6 mrem and 199.5 mrem. In Table 92, these estimated doses are compared with DOE guide values and the data show the doses are well within the DOE guides.

DATA COMPILATION: RADON-222 SOURCE TERM

Residues from the processing of Belgian Congo pitchblende remained the property of the African Metals Corporation (Afri-Met), an agency of the Belgian Government. By agreement between Afri-Met and the U. S. Atomic Energy Commission, the residues were to be stored for eventual return to the owner. Therefore, when the residues were generated they were not mixed with other site wastes but were placed in the two dedicated silos. In 1983 the lease agreement was ended and DOE assumed full ownership and responsibility for the residues.

Pitchblende residues were first added to the concrete storage silos in 1953. The residues were batch-pumped from the FMPC refinery to the silos as an aqueous slurry. The supernatant liquid was withdrawn and pumped back to the refinery to be reused in the slurrying step. Additions to the silos ended in 1955 when the last pitchblende was processed at the FMPC. Also in 1955, pitchblende residues from another site were added to the silos. Filling and return lines were then removed and all openings except one on each silo were covered with metal plates. The single remaining opening on each silo was a small gooseneck pipe. In 1977, the remaining openings were capped and all cover plates were gasketed and bolted. Core sampling of the silo contents in 1972 showed a dry

free-flowing powder at the surface and 40% moisture in samples from the bottom.

The estimated source term for radon-222 flux, for both silos under the present storage conditions, is 60 Curies per year. Dispersion code calculations predict that this flux will add an average of 0.006 pCi/L to the radon-222 concentrations at the nearest residence. This increase is about 2.5% of the natural background Rn-222 concentration in the Cincinnati area. Appendix 1 is a report which discusses the source term derivation and the concentration and dose calculations. For conservatism in the source term derivation, the amount of Ra-226 in the silos was assumed to be 1760 curies instead of the previously-used estimate of 1652 curies.

From 1953 through 1955, the FMPC refinery processed pitchblende ore from the Belgian Congo. No chemical separation or purification had been performed prior to the receipt of the ore at the FMPC. As a result, all stack discharges of the ore included the daughter products of the uranium decay chains. No archival information exists about the amount of these nuclides discharged or the concentrations in the pitchblende. In order to provide a discharge estimate, a file sample of pitchblende was analyzed in 1985 for several radium and thorium isotopes. The concentrations found were used to calculate emissions based on the amount of uranium discharged. Data for 1953 - 1955 are included in Table 93.

Beginning in 1956, the refinery feed consisted of uranium concentrates from Canada and the U.S.A. In the milling process that produced the yellowcake from ore, most of the uranium daughters had been removed. One important daughter product, radium-226, is carried over in amounts that vary with the type of process; concentrates produced by resin-in-pulp extraction or sulfuric acid leach methods have one-tenth or less Ra-226 than does yellowcake prepared by the carbonate leach process.

As in the case of the pitchblende, there are no archival data regarding concentrate radium levels. Also, identification of the type of concentrates processed is not available. Therefore, an average radium concentration was selected. The reported range of Ra-226 in concentrates, according to one study made by the U. S. Public Health Service, was 26 - 7190 pCi/g of sample. Assuming a value of 70% uranium, this range converts to 0.037 - 10.3 uCi/gU. However, the maximum reported for Homestake-Sapin concentrate was considerably greater than the concentration found, in 1985, in a file sample of that concentrate; 7190 pCi/g was reported and 1600 pCi/g was found. The reported U. S. Public Health Service results and the 1985 FMPC results are given below:

CONCENTRATE	Radium-226 pCi/g of sample	uCi/kgU
1985 FMPC DATA		
Homestake-Sapin	1600	2.3
Texas Zinc Miner	1500	2.1
Durango	170	0.24

CONCENTRATE	Radium-226 pCi/g of sample	uCi/kgU
U.S. PHS DATA		
Homestake-Sapin	7190	10.3
Homestake-Partners	3490	5.0
Gunnison	35	0.050
Edgemont	150	0.21
Climax	26	0.037

An average of 1.0 uCiRa/kgU was selected for estimating refinery emissions. If additional data are obtained that justify a different average, the estimates can be adjusted.

Canadian concentrates were used as refinery feed from 1956 through 1960. Each type was analyzed for thorium prior to processing so that extraction conditions could be established. The thorium content of the Canadian material was high enough to require special efforts to ensure that the

refinery product, UO_3, was within the thorium specifications of 50 ppm on a uranium basis. In order to meet this specification, blending was done to produce extraction feed solutions which did not exceed 0.5% thorium on a uranium basis. A concentration of 0.5% Th converts to 0.56 uCiTh/kgU and this concentration was used to estimate the thorium discharges reported in Table 93 for 1956 - 1960.

Archival information on the concentration of thorium in two U. S. concentrates was augmented with the FMPC analyses in 1985 of three concentrate file samples:

CONCENTRATE	Thorium-232 uCiTh/kgU
FMPC ARCHIVAL DATA	
Cannonsburg Vitro	3.4×10^{-3}
Colorado Vitro	2.2×10^{-2}
FMPC 1985 ANALYSES	
Durango	2.4×10^{-3}
Homestake-Sapin	2.8×10^{-2}
Texas Zinc Miner	9.2×10^{-2}
AVERAGE	3.0×10^{-2}

The average Th-232 concentration of 0.03 uCi/kgU was used to estimate the refinery thorium discharges for 1961 - 1977 reported in Table 93.

The three concentrate file samples were also analyzed in 1985 for Ra-228, Th-228 and Th-230. Average concentrations were used to calculate the discharge estimates reported in Table 93. Although the file samples were U. S. concentrates, the averages were also used to calculate discharges for 1956 - 1960 when Canadian concentrates were processed. There are no file samples of Canadian concentrates and archival data are not available; it is unlikely that any concentrate samples were analyzed for trace radionuclides when the material was being received and processed at the FMPC.

POTENTIAL PATHWAYS

As noted in a preceding section, ingestion of river water is not a significant potential source of offsite radiation exposure because of the low concentrations and because the river is not used as a source of potable water. In addition, ingestion pathways for substances other than drinking water can be eliminated from consideration when calculating the offsite radiation dose due to FMPC operations. This conclusion is based on a statistical analysis of the radionuclide concentrations in fish, vegetables and milk collected from the FMPC environs. (1) This analysis shows there is no significant difference between radionuclide concentrations in these foodstuffs and in corresponding foodstuffs from

distant control locations. In fish collected from the Great Miami River, specimens collected upstream of the FMPC outfall had slightly higher uranium concentrations (0.331 pCi/G) than specimens collected at the outfall (0.299 pCi/G) and downstream from the outfall (0.242 pCi/G); the differences are not statistically significant. Milk samples from local and distant locations yielded identical results (less than 1 ug/L).

The possible 70-year committed dose due to ingestion of soil was calculated using the concentration of soil near the Elda Elementary School in Ross, Ohio. For this special case, a 70-year dose factor was used because the child's life expectancy is greater than 50-years. The calculated dose to the critical organ, bone endosteum, was 6.2×10^{-3} mrem. This is an extremely low dose and most of it is due to uranium naturally present in soil. It is improbable that soil would be consumed in a quantity that would produce a significant dose.

The external dose from the immersion pathway also can be removed from consideration of historical dose estimates because the dose is insignificant in comparison with existing standards and the dose from background radiation and other sources. Beta and gamma emitting radionuclides at the boundary air monitoring stations have not been found in concentrations that would contribute a significant dose. For example, during the period 10/31/84 to 12/7/84, a series of dust collector upsets occurred at the FMPC. The highest skin dose calculated for this period was 1.36×10^{-4} mrem. This indicates the external dose due to air

immersion is minimal and can be ignored when estimating the dose to the public due to historical emissions.

For the potential internal dose due to the inhalation pathway, the 50-year committed dose to the lungs, bone endosteum and the effective dose were calculated using the highest 1984 average concentration at the seven boundary air sampling stations. Results are given in Table 94. Thorium-230, Rn-222 and the uranium isotopes are responsible for most of the calculated potential dose: Lung, 99%; bone endosteum, 84%; effective dose 97%. In addition, Th-232, Th-234 and Pu-239/240 contribute 15% of the calculated potential dose to the bone endosteum. Since these radionuclides produce almost all of the calculated potential dose, it may not be necessary to reconstruct the historical emission record for other nuclides which do not contribute significantly to the potential offsite doses.

Potential doses due to the consumption of water from offsite wells with above-background concentrations of uranium are given in Table 92. This pathway and the inhalation and direct radiation pathways are the only significant routes for potential exposure of offsite residents.

Since 1975, gamma radiation dose rates at the FMPC boundary air sampling stations have been monitored with thermoluminescent dosimeters. The TLD's are hung on the station fences, about five feet above the ground. Dosimeters are changed and processed every three months and data are reported in the FMPC annual Environmental Monitoring Report.(1)

Naturally-occurring dose rates are observed at most boundary locations. Results are similar from year to year and the maximum dose rate occurs along the west side of the site. During 1984, the calculated maximum committed dose equivalent at an offsite residence, due to direct radiation from FMPC operations, was 9.8 mrem or about 10% of the dose received from natural background radiation.

ACCURACY OF HISTORICAL DOSE ESTIMATES

Accuracy of the dose estimates will depend upon two points:

(1) Accuracy and completeness of the discharge estimates.

(2) Accuracy of the computer program used to calculate doses from the discharge data.

The discharge estimates reported in this document vary from actual measured values to estimates based on production rates, extrapolated data, or consensus judgments. It is fortunate that the dust collector uranium discharges, which have produced the major part of the potential offsite doses, were monitored through continuous stack sampling. NLO developed the sampler in the early 1950's and experience has indicated that these units have given good data on uranium discharges.

Figure 6 is a diagram of the FMPC stack sampler system. Figure 7 shows the disassembled components and Figure 8 shows a unit installed on a FMPC dust collector stack. Before a sampler is installed, a traverse of the stack is made to determine the total air flow and velocity profile. The

sampler is installed with the probe in the stack centerline. The filter holder is attached to a vacuum source which is adjusted to provide an isokinetic sampling rate. A cellulose pleated filter is used to collect particulates; filter diameter is four inches and the effective filtering area is 77 square inches. Until recently, new filters were numbered and weighed. After removal from the sampler, they were weighed and an aliquot of the collected dust was removed, weighed and analyzed for uranium. This procedure provided the percent uranium in the dust and the total dust and total uranium on the filter. Knowledge of the probe diameter and duct diameter permitted a calculation to obtain total dust discharged and total uranium. As of December, 1984, all filters are changed at least once each month. The filters are dissolved in acid and analyzed for uranium.

Accuracy of the computer program that will be used to calculate radiation dose from stack discharge data is not known. It is, no doubt, a partial function of the accuracy of the input data: Stack physical characteristics; radionuclide emission rate; and meterological information. Although the accuracy of the program cannot be determined, the measured uranium concentration at the boundary sampling stations should provide an indication. In addition to the population doses that are intended to be calculated from data in this report, calculations will

be made of expected uranium concentrations at the seven boundary sampling stations. Results will be compared with the concentrations actually measured by analysis of filters from the continuously-operated air samplers.

QUALITY ASSURANCE

Efforts to ensure the reliability of FMPC environmental data existed since the start of site operations. Good laboratory practice was relied upon when operations began in the early 1950's; quality control measures were introduced later; and now quality assurance practices have been added. Time and effort spent on controls and obtaining proof of reliability increased as the use of environmental data progressed from a strictly internal recording to the obligatory submission of data to regulatory agencies to show compliance with the requirements of operating or discharge permits.

The elements of quality assurance which have been applied to effluent stack sampling at the FMPC include the following: establishment of sampler location in accordance with recommendations of appropriate ANSI Standards and good industrial hygiene practice with consideration of facility design; establishment and checking of proper isokinetic centerline sampler flowrate by measurement of stack flowrate using standard pitot tube methods and written standard operation procedures; periodic filter change inspection, including inspection of the sampler conducted per standard operating procedure; measurement of sampler

airflow with calibrated rotameter and verification of proper sampler flowrate at each inspection; use of individually numbered filters to ensure proper sample identification and delivery of filters to the laboratory; recording of stack sampler inspection data on standard forms with distribution to appropriate production plant supervision; evaluation of airflow data and analytical data to verify proper sampler operation and appropriateness of analytical result including comparison with past results.

Until December, 1984, filter samples collected to monitor airborne discharges of uranium from dust collectors were analyzed in the Health and Safety Division laboratory facilities. The initial designation of "Analytical Laboratory" for these facilities was subsequently changed to "Bioassay Laboratory." Over the years, improvements were made in the analytical methods and there were an increasing number of quality assurance practices applied to the analyses of stack filter samples for uranium. From 1951 until June, 1960, standard analytical laboratory quality assurance practices were followed such as the use of distilled water and analytical grade reagents. Uranium standards were analyzed and a new calibration curve constructed whenever fresh reagents were prepared or any changes were made which might effect analytical results. Such changes included the replacement of spectrophotometer cells or the installation of new instrument components. Additionally, samples were analyzed in duplicate at various times as a check of analytical performance and to evaluate the precision of the analyses.

A very significant quality assurance practice was initiated prior to 1960 and continued until December, 1984. Whenever the initial analytical result for a filter indicated a uranium discharge of 50 pounds or more had occurred, the sample was subjected to a second analysis. The second analyses were performed in the Technical Division's Nuclear Materials Control Laboratory using a well established and reliable oxidation-reduction method which was closely monitored by quality assurance techniques. In these instances, uranium stack discharges were based on the Technical Division's analytical result.

During June, 1960, the analyses of quality control samples on a regular basis were added to the above quality assurance measures for the determination of uranium in stack samples in the Bioassay Laboratory. The control samples were provided by the Quality Assurance Section of the Technical Division's analytical Department. Personnel in the Quality Assurance Section evaluated the control sample results and regularly submitted reports to the Bioassay Laboratory so that corrective actions could be taken if necessary. Since December, 1984, uranium analyses of all stack filter samples have been performed by the Technical Division's Analytical Department which has an extensive quality assurance program which is described later.

The elements of quality assurance which have been applied to water sampling at the FMPC include: Collection of water samples according to current good practice and NPDES requirements as appropriate regarding sampling location, container type, proper preservation, and holding

times; collection of samples in new containers, uniquely identified, and delivered to the laboratory; maintenance of flow data quality by periodic calibration of instrumentation and by use of standard measurement devices such as the parshall flume; construction and installation of groundwater monitoring wells using current good practice standards to provide representative samples of the aquifer, geologic zone, impoundment, or facility being monitored; collection of groundwater samples using well evacuation and cross-contamination control techniques; evaluation of analytical results, including comparison with past results for appropriateness.

Much of the particle size and radionuclide data listed in this report relating to airborne discharges are based on analyses performed by the Technical Division's Analytical Department. The Analytical Department has been involved in a detailed internal quality assurance program for approximately 30 years. Quality assurance is administered by a section independent of the Department's laboratories. Analytical accuracy and precision are regularly evaluated by analyses of blind standards and recycle samples. The results of these analyses provide prompt indication of any problems and help ensure that the various laboratories are consistently producing reliable results. The Analytical Department also participates in three ongoing, external laboratory testing and evaluation programs. These are: (1) Safeguards Analytical Laboratory Evaluation (SALE), (2) General Analytical Evaluation (GAE), both conducted by the

DOE New Brunswick Laboratory, and (3) Uranium Metals Exchange (Oralloy), conducted by Los Alamos Scientific Laboratory.

Collector bulk dust samples were analyzed for Sr-90 and Ru-106 by the Analytical Chemistry Division of Oak Ridge National Laboratory which maintains an extensive quality assurance program. Ten percent of the analyses performed are for quality assurance purposes. The laboratory which performed the Sr-90 and Ru-106 analyses participates in the DOE Quality Assessment Program (QAP) administered by DOE's Environmental Measurement Laboratory (EML) and the USEPA-Las Vegas intercomparison analyses program in addition to the ORNL in-house quality assurance programs.

Data in this report on radionuclides discharged in liquid effluents are based on analyses performed in the NLO Bioassay and Analytical Departments, at ORNL and at a commercial laboratory. The quality assurance programs of the Analytical Department and ORNL described in previous sections regarding airborne discharges would also apply to analyses performed by these laboratories for the purpose of characterizing liquid effluent discharges. Quality assurance practices followed by the Bioassay Laboratory for the analyses of liquid effluent samples include daily measurements or checks of background count rate and detection efficiencies of counting equipment and routine analyses of blanks, standards, and spiked sample aliquots. The values obtained from these analyses have been within the ranges which indicate the analytical systems are under control and the results being obtained are reliable.

Uranium control samples provided by the Quality Assurance Section of the Technical Division are analyzed daily as part of the intralaboratory quality assurance activities. The values which have been obtained for these daily control samples show that the procedure used for uranium analyses produces reliable data. The Bioassay laboratory also participates in DOE's Quality Assessment Program. In this program, laboratories receive samples of various media for analysis. Results are reported to DOE's Environmental Measurements Laboratory (EML) for comparison with established values. Since April, 1977, the Bioassay Laboratory has analyzed 19 soil, 26 water and 31 air filter samples for uranium. The ratio of Bioassay Laboratory results to EML values for these analyses has averaged 1.15 for soil, 1.08 for water and 1.12 for air filter samples.

A limited number of analyses have been performed on liquid effluent samples by a commercial laboratory which has been providing analytical services to the nuclear industry for many years. Relative to environmental monitoring analyses, the laboratory's quality assurance plan meets the requirements of 10CFR50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants" and NRC Regulatory Guide 4.15 "Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment." The quality assurance program also closely corresponds to the 'Handbook for Analytical Quality Control in Radioanalytical Laboratories" EPA-60017-77-088, August, 1977.

Thermoluminescent dosimeters used at the FMPC boundary stations have been tested in the annual International Environmental Dosimeter Inter-comparison Project sponsored by DOE and the U. S. Nuclear Regulatory Commission. In this project, participating organizations submit dosimeters to be placed in a uniform outdoor radiation field. After exposure, the dosimeters are returned to the organizations for determination of the dose received. Results are reported to the sponsors and the sponsors issue a report that lists the actual dose and the values reported by all participants. FMPC thermoluminiscent dosimeters have performed well; in recent intercomparisons, FMPC results were within 10% or less of the actual doses received. This is considered highly acceptable performance for the determination of environmental radiation doses.

REFERENCES

(1) Facemire, C. F., D. L. Jones, and R. W. Keys, Feed Materials Production Center Environmental Monitoring Report For 1984, NLO, Inc., Report NLCO-2028 (Special), July 15, 1985.

(2) Department of Energy, Feed Materials Production Center Groundwater Study - Task C Report, prepared by Dames & Moore for NLO, Inc., July, 1985.

(3) Process And Waste Characteristics at Selected Uranium Mills, U. S. Public Health Service, Technical Report W62-17, 1962.

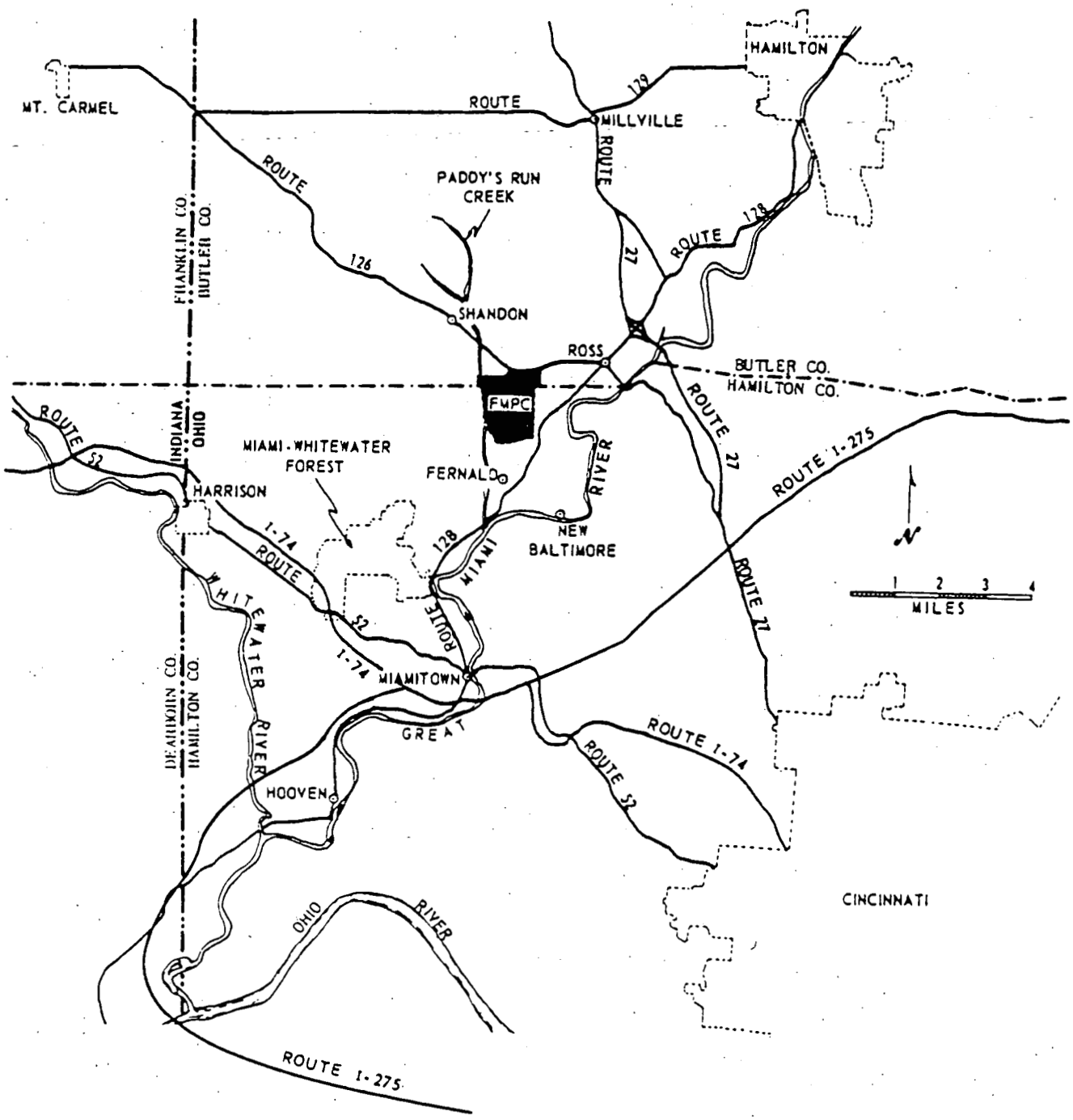

Figure 1. Map of FMPC Area

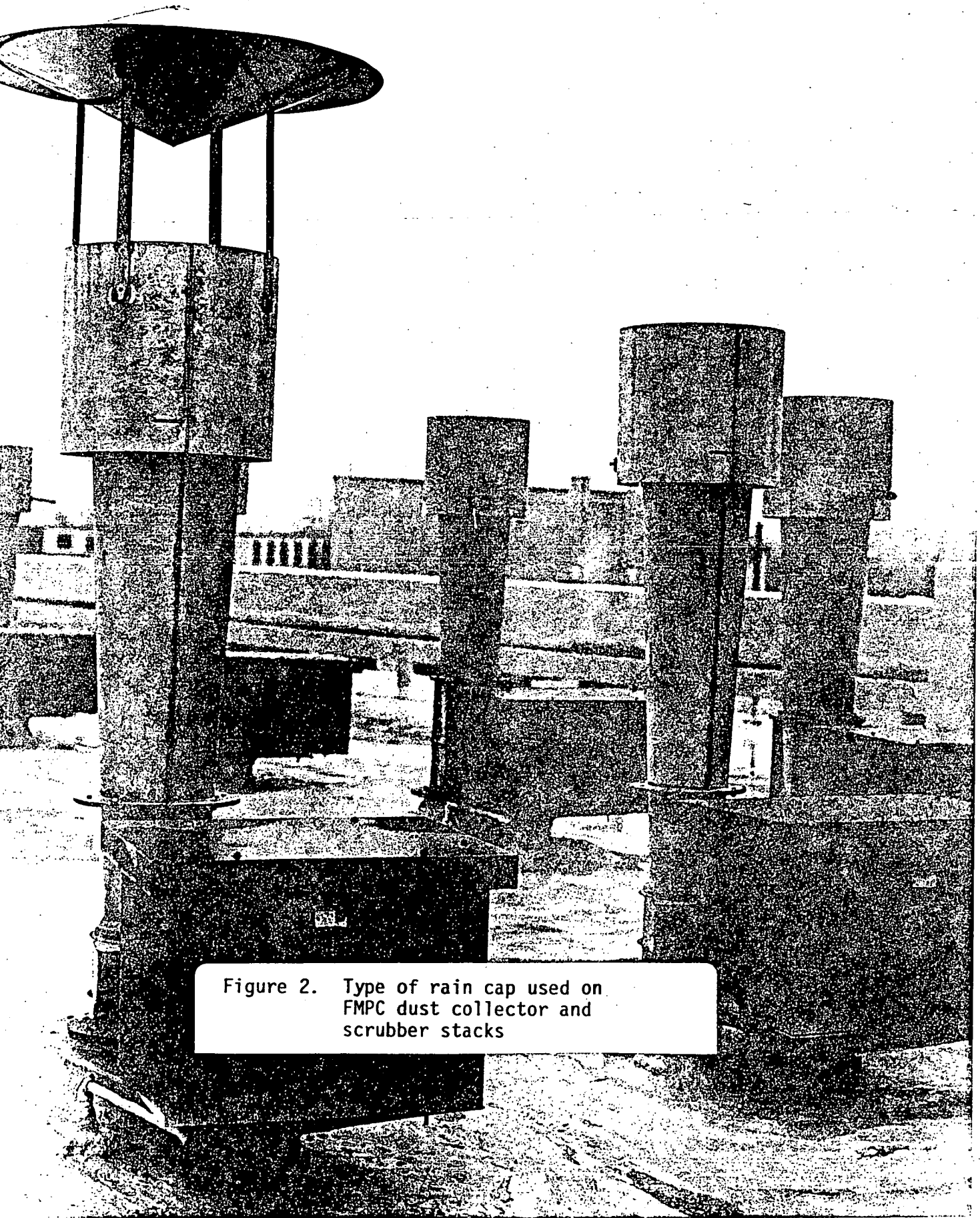

Figure 2. Type of rain cap used on FMPC dust collector and scrubber stacks

FIGURE 3

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FEED MATERIALS PRODUCTION CENTER

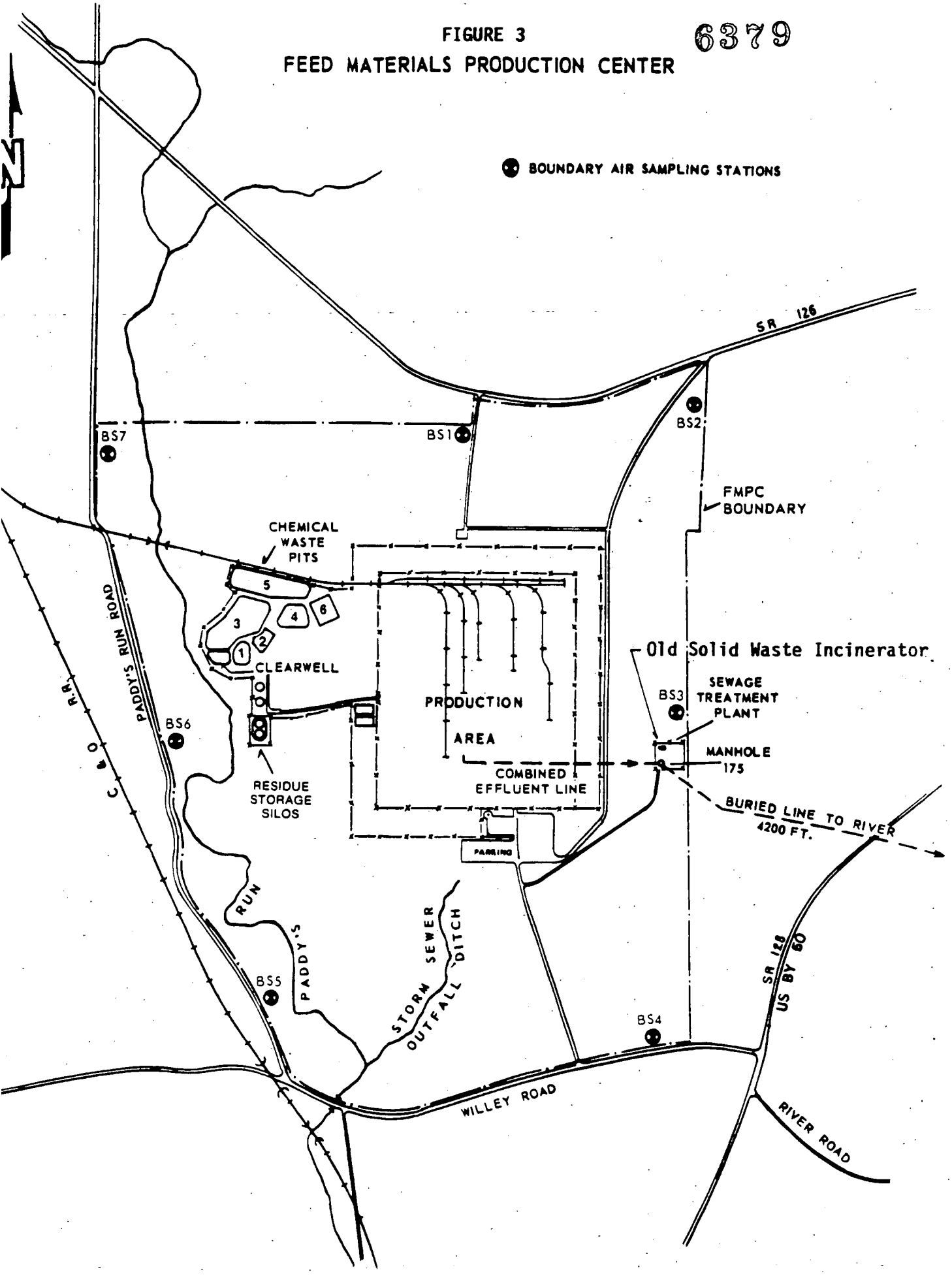
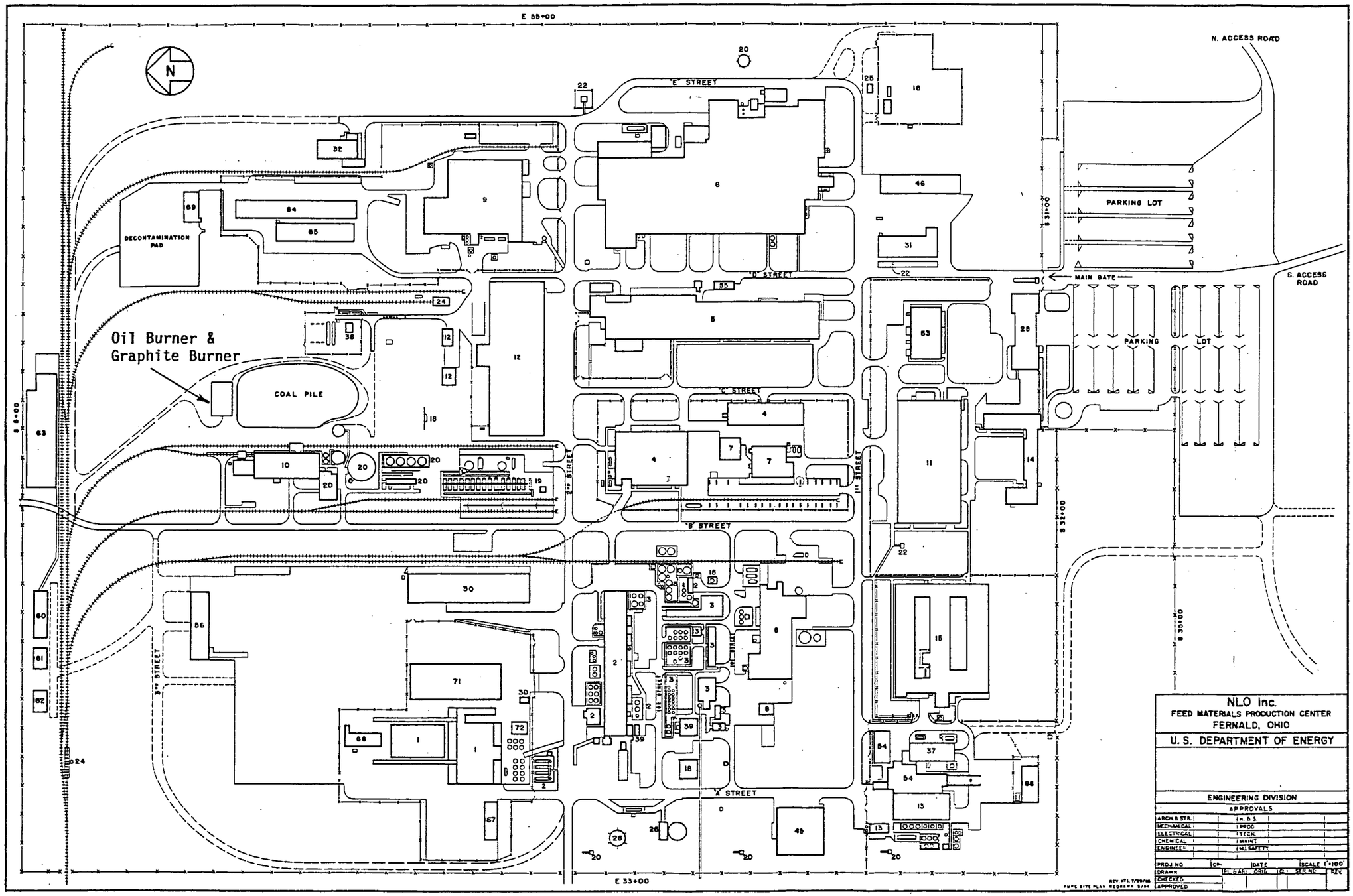


FIGURE 4. FMPC PRODUCTION AND ADMINISTRATIVE AREA



AREA CODE NUMBER	TITLE
1	Preparation Plant Silo Storage (South of Sampling Plant)
2	Ore Refinery Plant
3	Nitric Acid Recovery Plant
4	Green Salt Plant
5	Metals Production Plant
6	Metals Fabricating Plant
7	Building 7
8	Recovery Plant
9	Special Products Plant
10	Boiler Plant
11	Service Building
12	Mechanical Shop & Storeroom
13	Pilot Plant (Wet End)
14	Administration Building
15	Laboratories
16	Main Electric Sub-Station
18	Water Pollution Control Chemical Feed Building General Sump
19	Metal Tank Farm
20	Water Supply System Cooling Tower Cooling Tower Pump House Elevated Storage Tank - East Treated Water Storage Tank Chlorine Building (For Water Treatment Area) Water Wells Reactivator
22	Interplant Service & Product Lines Gas Meter House Lift Station Pipe Trestle Truck Scale
23	Communication & Alarm System
24	Railroad System
25	Sanitary Sewer System Sewage Disposal Imhoff Tanks Sludge Beds
26	Fire Protection System Elevated Water Tower - West
28	Security System - Guard House
30	Chemical Warehouse
31	Engine House - Garage
32	Magnesium Storage
34	K-65 Storage Area
35	Metal Oxide Storage Area
37	Pilot Plant Annex
38	Propane Storage
* 39	Incinerator Plant
40	Waste Management - Solids
44	Temporary Structures
45	Building 45
46	Heavy Equipment Garage
47	Mobile Equipment
51	UF_4 to UF, Reduction Facility II
53	Health, Safety & Production Control Building
54	UF_4 to UF, Reduction Facility I
55	Slag Recycling Plant - East
56	CP Storage Warehouse
60	Quonset Number 1
61	Quonset Number 2
62	Quonset Number 3
63	KC-2 Warehouse
64	Plant 9 Warehouse
65	Plant 5 Warehouse
66	Drum Reconditioning Building
67	Plant 1 Storage Building (No. 1 & No. 2)
68	Pilot Plant Warehouse
69	Decontamination Building
71	General In-Process Storage Warehouse
72	Drum Storage Building
73	Fire Brigade Training Center
74	Paved Area Storage
75	Site Preparation

* Location of new solid waste incinerator and liquid organic waste incinerator.

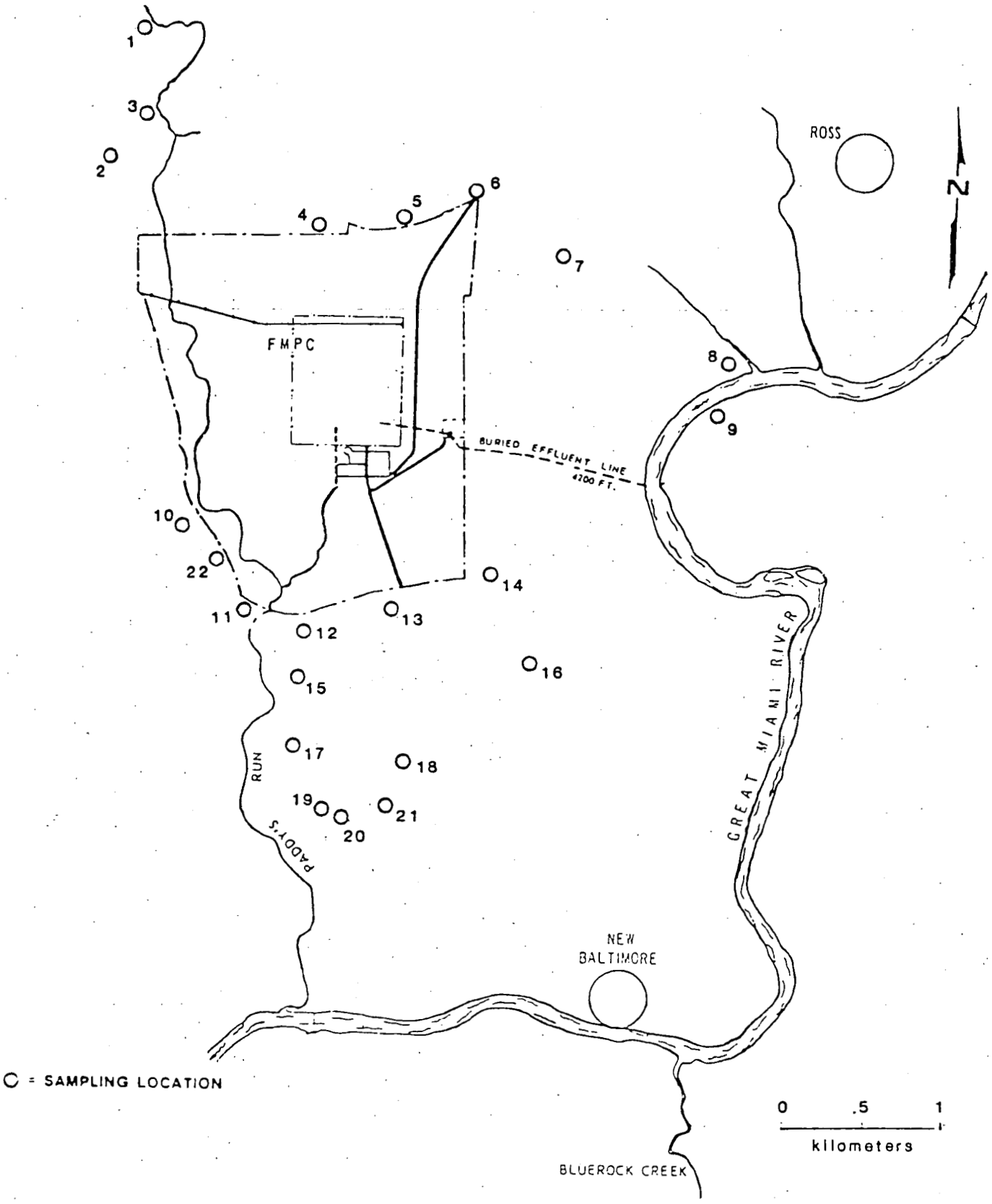


FIGURE 5. OFFSITE MONITORING WELL LOCATIONS

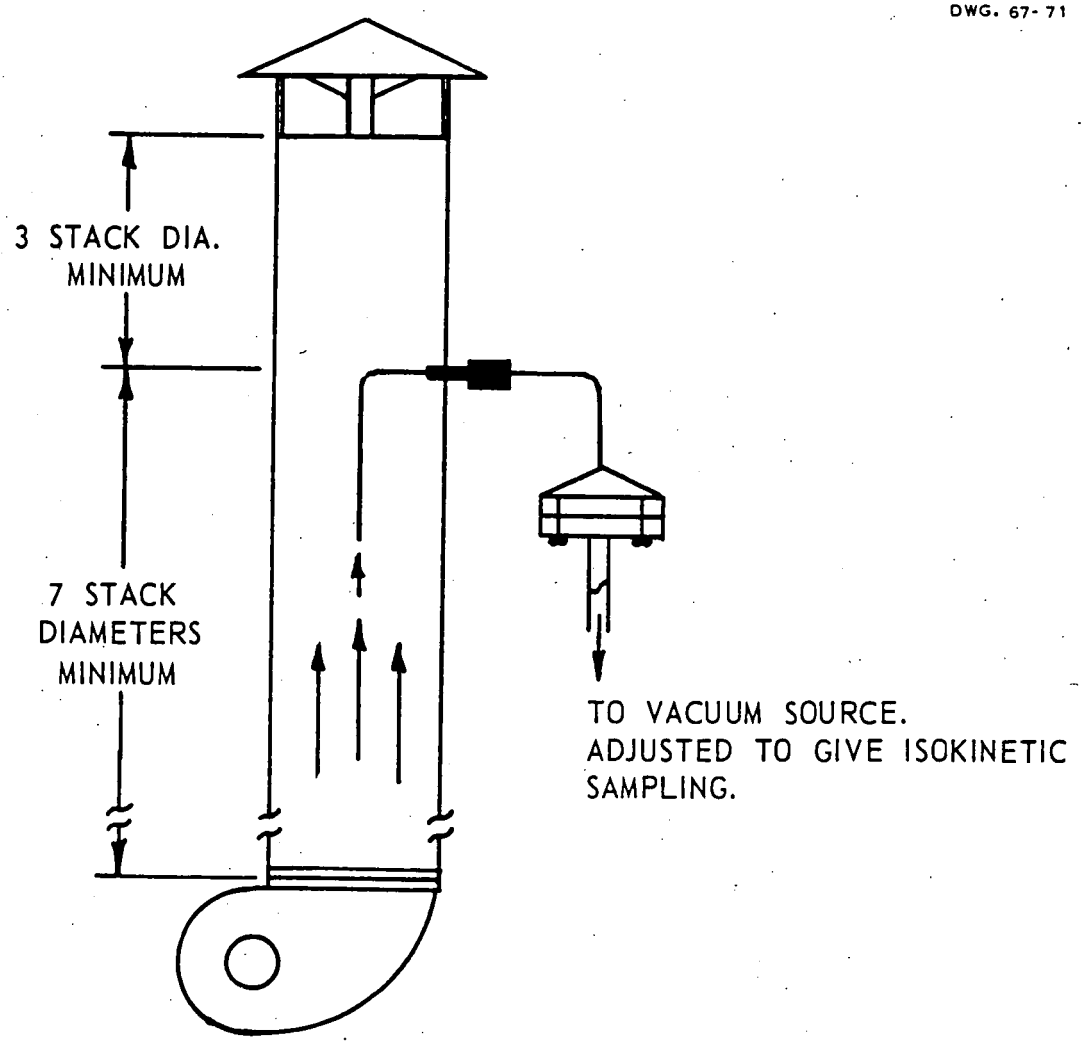


FIGURE 6. DIAGRAM OF IDEAL SAMPLER INSTALLATION

TABLE 1. STACK DATA FOR DUST COLLECTORS AND PLANT 8 SCRUBBERS

DUST COLLECTOR	STACK HEIGHT, FT.(1)	STACK DIAMETER, IN.(2)	EXHAUST VELOCITY FT/MIN
PLANT 1			
G2-1	10	8	1600
G2-2	67	14	2651
G2-63	67	24	1910
G2-64	67	24	2448
G2-67	67	24	2610
G2-68	67	18	3221
G2-76	67	24	1308
G2-77	67	18x22	1018
G2-171	65	10	4884
G2-172	40	18	2858
G2-174	65	8	5730
G2-235	67	6	1475
G2-6014	25	14	2648
G2-6015	25	19x15	4469
G2-6042	67	10	4481
PLANT 2/3			
G1-94	72	16	2078
G1-252	72	23	3118
G1-754	72	17	3938
G1-856	72	17	2855
3-N	72	20	2202
3-S	72	20	2059

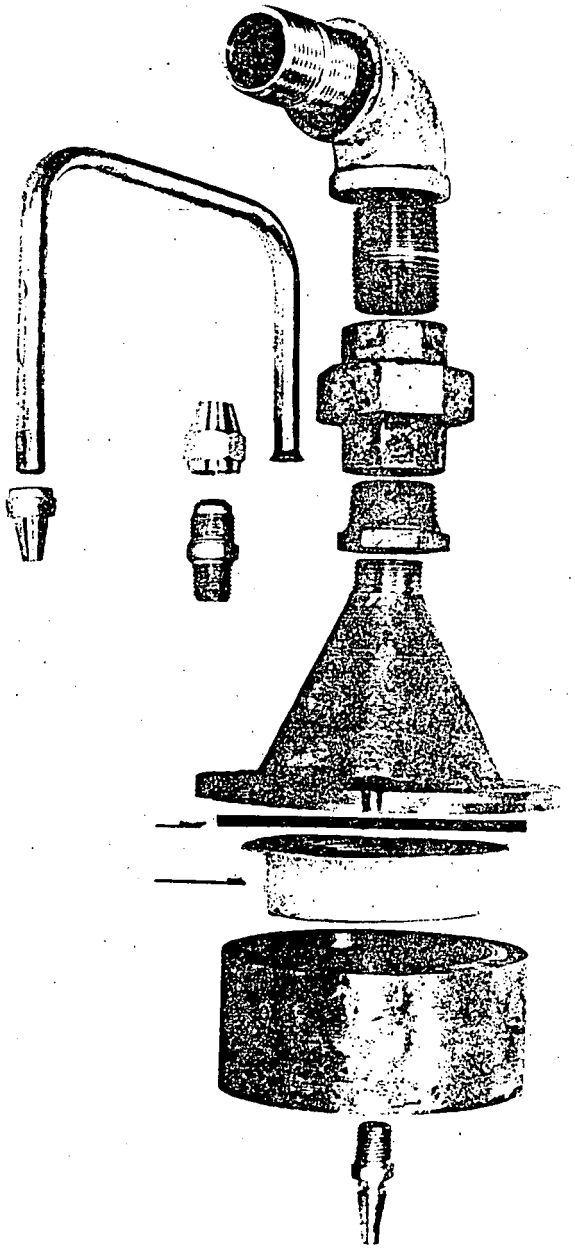


FIGURE 7. DISASSEMBLED STACK SAMPLER

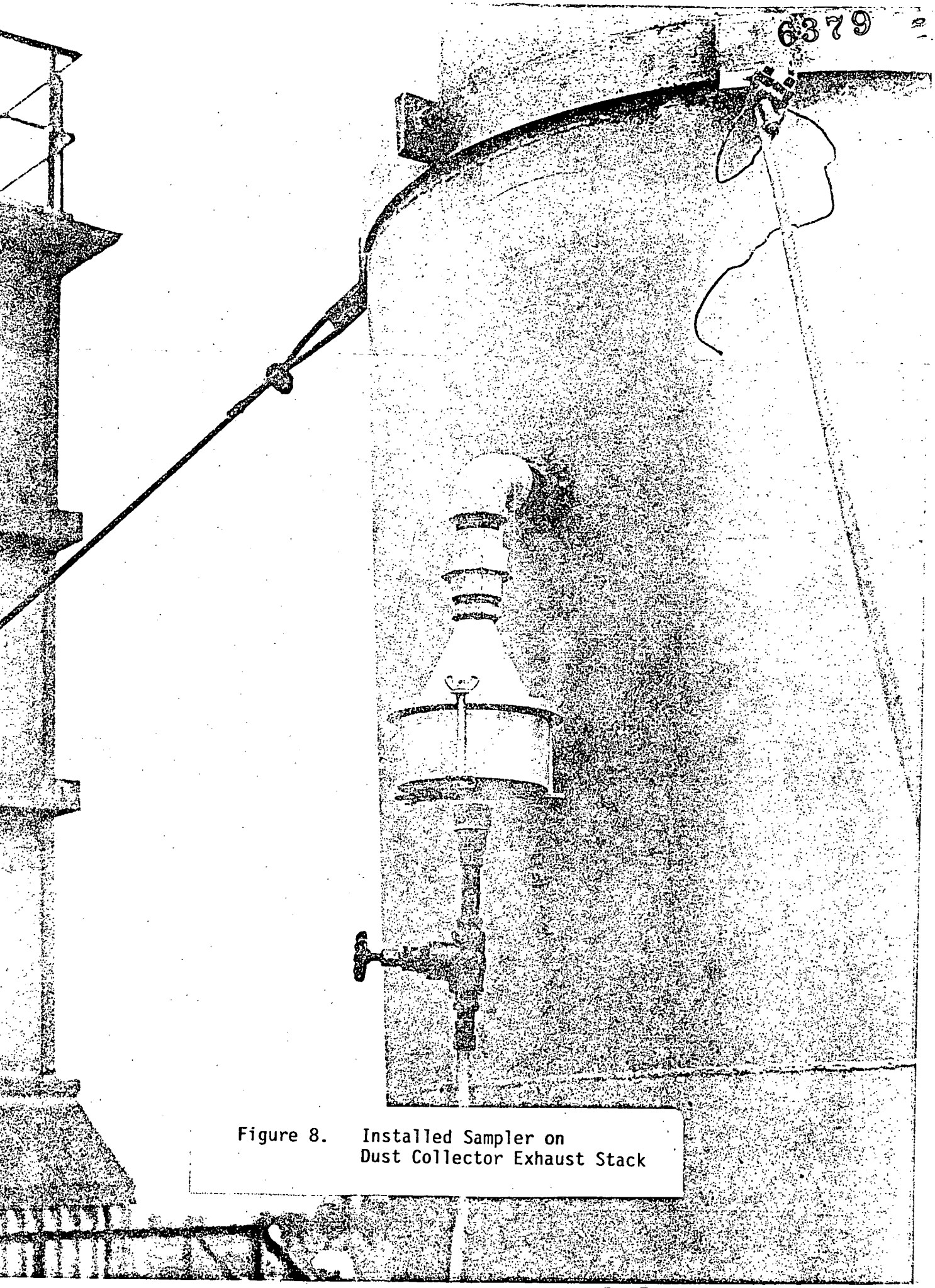


Figure 8. Installed Sampler on Dust Collector Exhaust Stack

TABLE 1. STACK DATA FOR DUST COLLECTORS AND PLANT 8 SCRUBBERS (continued)

DUST COLLECTOR	STACK HEIGHT, FT.(1)	STACK DIAMETER, IN.(2)	EXHAUST VELOCITY FT/MIN
PLANT 4			
G4-1	97	10	2994
G4-2	97	20	3280
G4-3	97	28	2590
G4-4	97	12	908
G4-5	97	11	2697
G4-7	97	28	935
G4-8	97	21	3100
G4-12	97	12	3470
G4-13	97	8	388
G4-14	105	24	1413
G4-15	97	9	2434
G4-7001	97	11	2380
PLANT 5			
G2-67	48	24	3473
G5-247	57	16	3377
G5-248	57	16	4340
G5-249	57	24	2622
G5-250	57	24	3631
G5-251	57	24	2863
G5-252	57	22	2500
G5-253	57	24	3229
G5-254	57	22	3153
G5-256	57	22	3132
G5-258	57	22	2447
G5-259	57	30	2811
G5-260	57	22	1886
G5-261	57	30	3968
G5-262	57	23	1779
G5A-100	57	30	2654
G5A-101	52	22	2253
Bldg. 55	62	13	4365

TABLE 1. STACK DATA FOR DUST COLLECTORS AND PLANT 8 SCRUBBERS (continued)

DUST COLLECTOR	STACK HEIGHT, FT.(1)	STACK DIAMETER, IN.(2)	EXHAUST VELOCITY FT/MIN
PLANT 6			
G6-86	53	17	3534
G6-88	53	17	3222
G6-6057	53	47	2053
North ESP	25	47	2500
Mid ESP	25	32	6547
South ESP	25	47	2761
PLANT 7			
G4-2507	120	22	1733
G4-2508	120	22	1733
G4-2509	120	18	2123
G4-2510	120	18	2123
PLANT 8			
G3A-2	55	16	1725
G8-1	53	13	2585
G8-2	53	23	3761
G8-3	53	19	1821
G8-4	53	19	3850
G8-7	45	11	3119
G8N1-1000	53	18	1180
G43-27	45	28	3432
G43-29	45	16	1725
G43-44C	53	14	3600
6018	53	9.5 x 9.5	3350
6019	53	9.5 x 9.5	3350
8002	53	10 x 10	2592
8021	45	10	4700
8024	45	10	4750
8035	45	13	4416
8057	53	12	3685
8083	53	10 x 10	2592
8102	53	10 x 10	2592

TABLE 1. STACK DATA FOR DUST COLLECTORS AND PLANT 8 SCRUBBERS (continued)

DUST COLLECTOR	STACK HEIGHT, FT.(1)	STACK DIAMETER, IN.(2)	EXHAUST VELOCITY FT/MIN
PLANT 8 SCRUBBERS			
Rotary Kiln	53	12	2720
No. 1 Oxidation Furnace	53	10	1265
No. 2 Oxidation Furnace	53	12	2796
Box Furnace	53	11.5	1145
Muffle Furnace	53	14	2552
PLANT 9			
G9N1-1039	44	36	3107
G9E2-400	44	46	2140
G42-615	44	30	4085
G42A-100	44	26	3300
PILOT PLANT			
G-1	50	12	2567
G-2	50	12	2675
G2-20	52	20	2350
G6-93A	52	24	3118
G37-5011	52	17	4053
735-13-7041	52	24	1975
735-13-7050	52	34	1098
108843	52	30	2030
Oxidation Furnace	52	12	3118

(1) Stack height is the distance from ground level to stack mouth.

(2) Stack diameter is the inside diameter at the stack mouth.

TABLE 2. BUILDING DIMENSIONS

	Dimension, Ft.		Roof Peak Height, Ft.
	North-South	East-West	
Plant 1	100	160	60
Plant 2/3	60	380	67
Plant 4	225	165	94
Plant 5	650	100	52
Plant 6	500	200	39(1)
Plant 7	110	80	114
Plant 8	60	260	48
Plant 9	300	225	40
Pilot Plant	210	235	54
Building 55	60	30	51

(1) Three small dormers along the west side of plant 6 have a roof peak height of 50 feet.

TABLE 3. PLANT 1 DUST COLLECTOR URANIUM DISCHARGES, CY-1953 THROUGH CY-1984
(kg U)

DUST COLLECTOR	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
G2-1	–	–	–	–	–	–	–	–	–	–	–
G2-2(1)	–	–	–	–	–	–	–	–	–	–	–
G2-63	–	1	1	2	6	6	–	–	4	1	0.4
G2-64	–	–	–	1	0.4	297	–	–	0.4	–	1
G2-67	–	–	–	5	4	10	–	–	–	–	–
G2-68	–	–	–	1	4	4	13	4	2	1	25
G2-76	–	–	–	4	1	2	–	4	3	10	55
G2-77	1	14	14	27	34	88	33	12	32	1	0.4
G2-171	–	–	–	–	–	–	–	–	–	–	–
G2-172	–	–	–	3	–	–	–	–	5	1	0.4
G2-174	–	0.4	0.4	–	–	–	–	–	6	–	–
G2-235	–	–	–	–	–	–	–	–	–	–	–
G2-6014(2)	–	–	–	–	–	–	–	–	–	–	–
G2-6015(3)	–	–	–	–	–	–	–	–	–	–	–
G2-6042	–	–	–	0.4	–	0.4	–	–	0.4	–	0.4
Plant Total	1	15.4	15.4	43.4	49.4	407.4	46	20	52.8	14	82.6

(1) No stack sampler, 1953 - 1984. It is not likely that the uranium discharge exceeded an average of 0.5 kg U per year.

(2) Dust collector installed 1956. No stack sampler, 1956 - 1984. It is not likely that the uranium discharge exceeded an average of 0.5 kg U per year.

(3) Dust collector installed 1957 or later. No stack sampler, 1957 - 1984. It is not likely that the uranium discharge exceeded an average of 0.5 kg U per year.

TABLE 3. PLANT 1 DUST COLLECTOR URANIUM DISCHARGES, CY-1953 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
G2-1	–	–	–	–	–	–	–	–	–	–	–
G2-2	–	–	–	–	–	–	–	–	–	–	–
G2-63	–	–	–	–	–	–	–	–	–	–	–
G2-64	6	–	4.1	6.0	0.1	8.0	1.3	2	28	1	–
G2-67	–	–	–	–	–	–	–	–	–	–	–
G2-68	–	–	–	–	–	–	–	–	–	–	–
G2-76	2	–	1.3	1.5	–	2.0	0.3	–	–	–	1
G2-77	–	–	–	–	–	–	–	–	–	–	–
G2-171	–	–	–	–	–	–	–	–	–	–	–
G2-172	6	–	4.1	9.0	0.3	12.2	2.1	6	–	–	–
G2-174	–	–	–	–	–	–	–	–	–	–	–
G2-235	4	4.1	2.7	3.9	0.1	5.0	0.8	1	0.4	–	0.4
G2-6014	–	–	–	–	–	–	–	–	–	–	–
G2-6015	–	–	–	–	–	–	–	–	–	–	–
G2-6042	–	–	–	–	–	–	–	–	–	–	–
Plant Total	18	4.1	12.2	20.4	0.5	27.2	4.5	9	28.4	1	1.4

TABLE 3. PLANT 1 DUST COLLECTOR URANIUM DISCHARGES, CY-1953 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
G2-1	–	–	–	–	–	–	–	–	–	–
G2-2	–	–	–	–	–	–	–	–	–	–
G2-63	–	–	–	–	–	–	–	–	–	–
G2-64	3.5	2.7	0.6	1.8	0.8	–	–	1.2	1.9	1.2
G2-67	–	–	–	–	–	–	–	–	–	–
G2-68	0.5	–	–	–	–	–	–	–	–	–
G2-76	–	–	–	–	–	5.7	1.3	0.9	2.0	1.9
G2-77	1.6	–	–	–	–	–	–	–	–	–
G2-171	–	–	–	–	–	–	–	–	–	–
G2-172	–	–	–	–	–	6.7	–	–	0.7	0.1
G2-174	–	–	–	–	–	–	–	–	–	–
G2-235	–	–	–	–	–	–	–	–	–	0.1
G2-6014	–	–	–	–	–	–	–	–	–	–
G2-6015	–	–	–	–	–	–	–	–	–	–
G2-6042	–	–	–	–	–	1.0	–	–	1.8	8.8
Plant Total	5.6	2.7	0.6	1.8	0.8	13.4	1.3	2.1	6.4	12.1

TABLE 4. PLANT 2/3 DUST COLLECTOR URANIUM DISCHARGES, CY-1953 THROUGH CY-1984
(kg U)

DUST COLLECTOR	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	(1) 1963
G1-94	2	24	24	156	207	–	13	78	4	36	–
G1-252	–	–	–	–	–	–	–	–	–	–	–
G1-754	9	106	106	54	215	153	–	56	23	29	–
G1-856	2	26	26	18	558	67	106	79	40	2	–
3-N	–	–	–	–	–	–	–	–	–	–	–
3-S	–	–	–	–	–	–	–	–	–	–	–
Plant Total	13	156	156	228	980	220	119	213	67	67	0

(1) No operations in plant 2/3 during 1963

TABLE 4. PLANT 2/3 DUST COLLECTOR URANIUM DISCHARGES, CY-1953 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	(1) 1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
G1-94	-	12.7	29.0	-	-	-	-	-	-	13	3
G1-252	-	-	-	-	-	-	-	-	-	-	3
G1-754	-	-	23.4	-	-	-	-	-	-	-	-
G1-856	-	-	1.6	26.8	9.5	8.2	46.7	26	410	173	9
3-N	-	-	-	-	-	-	-	-	-	-	-
3-S	-	-	-	-	-	-	-	-	-	-	-
Plt. Total	0	12.7	54.0	26.8	9.5	8.2	46.7	26	410	186	15

(1) No operations in plant 2/3 during 1964.

TABLE 4. PLANT 2/3 DUST COLLECTOR URANIUM DISCHARGES, CY-1953 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
G1-94	6.4	–	–	–	–	–	–	–	–	0.2
G1-252	8.4	3.6	–	–	–	–	–	–	–	0.3
G1-754	–	–	–	–	–	–	–	–	–	–
G1-856	–	–	–	–	–	–	–	2.3	–	0.9
3-N	–	–	–	–	–	1.0	–	–	–	1.6
3-S	49.9	5.6	6.2	–	–	1.7	–	–	–	1.3
Plt. Total	64.7	9.2	6.2	0	0	2.7	0	2.3	0	4.3

TABLE 5. PLANT 4 DUST COLLECTOR URANIUM DISCHARGES, CY-1953 THROUGH CY-1984
(kg U)

DUST COLLECTOR	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
G4-1	–	–	–	–	–	–	–	–	–	–	72
G4-2	–	–	1592	782	380	71	79	89	49	117	77
G4-3	–	–	3060	4088	78	44	700	43	134	207	526
G4-4	–	–	211	4	76	8	136	2	4	9	14
G4-5	–	–	56	242	175	166	343	1	7	30	51
G4-7	–	–	1096	28	94	292	161	49	22	202	224
G4-8	–	–	–	–	–	–	–	24	34	130	500
G4-12	–	–	–	–	–	–	–	–	–	–	5
G4-13	–	–	–	–	–	–	–	–	–	–	–
G4-14	–	–	–	–	–	–	–	–	–	–	–
G4-15	–	–	–	–	–	–	–	–	–	–	–
G4-7001	–	–	–	1	11	80	9	4	12	8	–
UO_3 System[1]	1628	3536	–	–	–	–	–	–	–	–	–
Plt. Total	1628	3536	6015	5145	814	661	1428	212	262	703	1469

(1) "UO_3 System" refers to unspecified dust collectors which served part of the UO_3 - to - UF_4 conversion process. The designation was not used after 1954.

TABLE 5. PLANT 4 DUST COLLECTOR URANIUM DISCHARGES, CY-1953 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
G4-1	1	–	0.4	0.6	0.5	0.1	–	–	–	–	–
G4-2	1	–	0.4	0.6	0.5	0.1	–	–	9	–	8
G4-3	152	19.1	63.5	78.1	74.6	13.8	8.4	–	–	–	–
G4-4	49	1.5	20.5	25.2	24.0	4.4	2.7	–	–	–	–
G4-5	29	4.4	12.1	14.8	14.2	2.6	1.6	–	–	–	0.4
G4-7	234	292.2	97.7	120.0	114.7	21.3	12.9	–	–	–	–
G4-8	31	14.6	13.0	16.0	15.2	2.8	1.7	–	–	–	–
G4-12	48	2.9	20.1	24.6	23.5	4.3	2.6	–	–	–	–
G4-13	–	–	–	–	–	–	–	–	–	–	–
G4-14	–	–	–	–	–	–	–	–	–	57	16
G4-15	–	–	–	–	–	–	–	–	–	–	–
G4-7001	–	–	–	–	–	–	–	–	–	–	–
Plt. Total	545	334.7	227.7	279.9	267.2	49.4	29.9	0	9	57	24.4

TABLE 5. PLANT 4 DUST COLLECTOR URANIUM DISCHARGES, CY-1953 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
G4-1	-	-	-	-	-	6.2	1.8	0.2	-	0.2
G4-2	24.6	-	-	-	-	53.2	238.0	3.2	18.5	30.3
G4-3	5.9	-	-	-	-	-	-	1.9	-	-
G4-4	29.3	15.8	-	-	-	-	-	-	-	-
G4-5	6.1	3.0	-	-	-	50.1	11.5	1.5	20.9	4.2
G4-7	-	-	-	-	-	-	6.0	5.6	2.5	0.7
G4-8	-	-	-	-	-	-	-	-	-	-
G4-12	-	-	11.8	11.9	5.5	18.5	4.0	1.3	0.9	0.1
G4-13	-	-	-	-	-	-	-	-	-	0.5
G4-14	53.9	7.3	-	-	40.8	5.8	170.8	7.3	0.1	3.6
G4-15	-	-	-	-	-	-	-	-	-	-
G4-7001	-	-	-	-	-	-	-	-	-	-
Plt. Total	119.8	26.1	11.8	11.9	46.3	133.8	432.1	21	42.9	39.6

TABLE 6. PLANT 5 DUST COLLECTOR URANIUM DISCHARGES, CY 1953 THROUGH CY-1984
(kg U)

DUST COLLECTOR	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
G2-67	–	–	–	–	–	–	–	–	–	–	–
G5-247	–	–	–	–	7	–	–	–	–	–	–
G5-248	–	–	–	–	7	2	11	1	–	8	14
G5-249	–	–	16	4	–	2	0.4	0.4	0.4	3	–
G5-250	–	–	3	10	–	1	11	5	–	–	–
G5-251	–	–	1	5	0.4	–	16	10	0.4	–	2
G5-252	–	–	2	6	–	–	–	–	–	–	2
G5-253	–	–	5	136	442	30	32	0.4	0.4	3	4
G5-254	–	–	110	43	52	18	29	3	1	20	7
G5-256	–	–	8	73	6	20	28	29	7	12	24
G5-258	–	–	114	144	57	46	75	8	11	10	48
G5-259	–	–	5257	1446	2341	260	138	44	4	116	411
G5-260	–	–	206	1086	463	98	28	60	34	29	3
G5-261	–	–	544	548	270	189	93	38	15	143	247
G5-262(1)	–	–	–	–	–	–	–	–	–	–	–
G5A-100	–	–	–	–	–	–	–	–	–	–	1
G5A-101	–	–	–	–	–	–	–	–	–	–	–
Bldg. 55	–	–	–	–	19	49	17	4	3	12	20
E. Burnout(2)	0.9	223	–	–	–	–	–	–	–	–	–
F Machines(2)	0.3	–	–	–	–	–	–	–	–	–	–
Plt. Total	1.2	223	6266	3501	3664.4	715	478.4	202.8	76.2	356	783

(1) G5-262 serves the graphite machine shop where only clean, new graphite is machined. No uranium discharges are expected; a stack sampler was not installed until after 1984.

(2) Specific collectors were not identified. These identifications were not used after 1954.

TABLE 6. PLANT 5 DUST COLLECTOR URANIUM DISCHARGES, CY 1953 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
G2-67	–	–	–	–	–	–	–	–	–	3	1
G5-247	–	–	–	–	–	–	–	–	–	1	–
G5-248	–	–	–	–	–	–	–	–	–	1	–
G5-249	–	–	–	–	–	–	–	–	–	–	–
G5-250	1	–	0.2	0.4	0.3	0.4	0.2	–	–	–	–
G5-251	–	–	–	–	–	–	–	–	–	–	–
G5-252	8	–	1.8	3.5	2.1	2.9	1.3	–	–	–	–
G5-253	54	–	12.5	24.1	14.3	19.4	8.7	–	–	–	–
G5-254	23	7	5.3	10.3	6.1	8.4	3.7	–	–	3	1
G5-256	4	7	0.9	1.8	1.0	1.4	0.6	–	–	3	–
G5-258	70	7	16.3	31.5	18.7	25.3	11.2	–	–	–	–
G5-259	94	126	21.9	42.1	25.1	34.0	15.2	–	–	21	–
G5-260	9	–	2.1	4.0	2.4	3.2	1.4	–	8	–	–
G5-261	58	56	13.5	26.1	15.5	21.0	9.4	–	–	41	34
G5-262	–	–	–	–	–	–	–	–	–	–	–
G5A-100	4	–	0.9	1.8	1.1	1.4	0.6	–	24	5	2
G5A-101	0.4	–	–	0.1	0.1	0.1	–	–	–	–	–
Bldg. 55	5	23.5	1.2	2.2	1.3	1.8	0.8	–	1	1	2
Plt. Total	330.4	226.5	76.7	147.9	88	119.3	53.1	0	33	79	40

TABLE 6. PLANT 5 DUST COLLECTOR URANIUM DISCHARGES, CY 1953 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
G2-67	–	–	–	–	–	–	–	0.7	2.4	2.1
G5-247	–	–	2.6	–	–	0.6	0.8	0.8	0.3	0.3
G5-248	2.6	2.1	4.3	3.1	4.2	5.1	4.1	1.6	–	0.4
G5-249	–	–	–	–	–	–	25.8	–	0.9	0.2
G5-250	–	–	–	–	–	–	–	–	–	1.4
G5-251	–	–	–	–	–	–	–	–	–	5.0
G5-252	–	–	–	–	–	–	–	–	–	–
G5-253	–	–	–	–	–	–	–	1.3	0.8	0.8
G5-254	0.5	–	–	2.7	–	2.5	5.1	5.7	2.6	3.0
G5-256	–	7.3	–	–	3.0	2.0	3.8	2.0	5.3	1.3
G5-258	–	–	–	–	–	–	–	–	–	0.2
G5-259	10.9	–	–	–	–	–	–	3.1	–	15.0
G5-260	2.6	–	–	3.1	–	13.6	27.9	38.6	4.4	8.4
G5-261	–	–	40.1	–	–	41.8	63.5	52.8	16.1	29.5
G5-262	–	–	–	–	–	–	–	–	–	–
G5A-100	1.8	–	4.6	–	–	3.0	2.7	–	–	0.4
G5A-101	–	–	–	10.6	–	2.3	1.0	1.1	2.9	0.4
Bldg. 55	0.6	4.3	1.7	9.6	5.1	18.6	0.9	14.1	5.7	15.5
Plt. Total	19	13.7	53.3	29.1	12.3	89.5	135.6	121.8	41.4	83.9

TABLE 7. PLANT 6 DUST COLLECTOR URANIUM DISCHARGES, CY 1952 THROUGH CY-1984
(kg U)

DUST COLLECTOR	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
G6-86	–	–	–	–	–	–	–	–	1	–	18	–
G6-88	–	–	–	–	–	–	–		–	2	–	84
G6-6057	–	–	–	–	–	–	–	38	38	116	58	9
North ESP	–	–	–	–	–	–	59	–	–	–	–	–
Mid ESP	9	18	18	18	22	28	–	–	–	–	–	12
South ESP	2	4	4	4	5	7	102	89	230	–	1	58
Plt. Total	11	22	22	22	27	35	161	127	268	119	59	181

TABLE 7. PLANT 6 DUST COLLECTOR URANIUM DISCHARGES, CY 1952 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
G6-86	5	–	1.7	0.4	4.5	0.4	–	–	–	–	–
G6-88	14	8.2	4.7	1.1	12.5	1.1	–	–	–	–	–
G6-6057	4	–	1.3	0.3	3.6	0.3	–	–	–	–	–
North ESP	–	–	–	–	–	–	–	–	–	–	–
Mid ESP	–	22.9	–	–	–	–	–	–	–	–	–
South ESP	11	11.5	3.6	0.9	9.8	0.9	–	–	–	–	–
Plt. Total	34	42.6	11.3	2.7	30.4	2.7	0	0	0	0	0

TABLE 7. PLANT 6 DUST COLLECTOR URANIUM DISCHARGES, CY 1952 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
G6-86	–	–	–	–	–	–	–	–	–	–
G6-88	–	–	–	–	–	–	–	–	–	–
G6-6057	–	–	–	–	–	–	–	–	–	0.8
North ESP	–	–	–	–	–	–	–	–	–	–
Mid ESP	–	–	–	–	–	–	–	–	–	–
South ESP	–	2.4	–	–	–	–	–	0.5	–	0.2
Plt. Total	0	2.4	0	0	0	0	0	0.5	0	1.0

TABLE 8. PLANT 7 DUST COLLECTOR URANIUM DISCHARGES, CY 1954 THROUGH CY-1956
(kg U)

DUST COLLECTOR	1954	1955	1956
G4-2507	550	4056	458
G4-2508	500	1373	402
G4-2509	1000	179	834
G4-2510	30	265	24
Plt. Total	2080	6000[1]	1718

(1) The actual total of 5873 kg is rounded off at 6000 kg because of sampling uncertainties.

TABLE 9. PLANT 8 DUST COLLECTOR URANIUM DISCHARGES, CY 1954 THROUGH CY-1984
(kg U)

DUST COLLECTOR	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
G3A-2	–	–	–	–	–	–	–	–	–	70
G8-1	–	–	–	–	–	–	–	–	35	231
G8-2	–	–	–	–	–	–	–	–	–	–
G8-3	–	–	–	–	–	–	–	–	–	–
G8-4	–	–	–	–	–	–	–	–	–	–
G8-7	–	–	–	–	–	–	–	–	–	–
G8N1-1000	–	–	4	–	–	–	–	–	–	35
G43-27	230	919	920	538	574	92	102	19	119	152
G43-29	12	47	5	57	26	17	1	2	15	93
G43-44C	–	–	–	–	–	–	–	–	–	14
6018	–	–	–	13	12	7	24	13	17	36
6019	–	–	150	49	6	3	–	–	–	–
8002	–	–	–	–	–	–	–	–	–	41
8021	–	–	4	6	–	–	16	37	23	2
8024	–	–	83	24	50	98	11	69	29	248
8035	–	–	28	80	194	21	36	8	344	43
8057	–	–	118	22	5	5	7	14	6	25
8083	–	–	4	2	–	3	–	5	10	4
8102	–	–	–	–	8	14	101	42	20	–
Plt. Total	242	966	1316	791	875	260	298	209	618	994

TABLE 9. PLANT 8 DUST COLLECTOR URANIUM DISCHARGES, CY 1954 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
G3A-2	–	–	–	–	–	–	–	–	–	–	–
G8-1	87	59.4	27.1	31.8	68.7	32.3	43.3	–	–	–	–
G8-2	315	27.4	99.1	118.1	255.2	120	161.5	8	4	–	–
G8-3	5	32	1.6	20.9	45.2	21.3	28.5	52	1	–	–
G8-4	–	9.1	–	3.7	8.0	3.8	5.0	10	–	–	–
G8-7	–	–	–	–	–	–	–	–	–	–	–
G8N1-1000	189	27.4	58.8	68.9	148.9	70.1	94	–	–	–	–
G43-27	301	27.4	94.6	116.0	250.7	118	158.7	17	–	7	–
G43-29	15	1.8	3.7	5.5	11.9	5.6	7.4	–	–	7	–
G43-44C	4	–	1.2	1.5	3.4	1.5	2.0	–	–	–	–
6018	13	109.6	4.0	4.7	10.1	4.8	6.3	–	–	–	–
6019	–	–	–	–	–	–	–	–	–	–	–
8002	3	–	0.9	1.1	2.3	1.1	1.5	–	–	–	–
8021	12	–	3.7	4.3	9.2	4.3	5.7	–	–	–	–
8024	105	13.7	32.7	39.7	85.8	40.4	54.1	4	–	–	11
8035	1	82.2	0.3	0.4	0.8	0.4	0.5	–	–	–	–
8057	1	–	0.3	0.4	0.8	0.4	0.5	–	–	–	–
8083	–	–	–	–	–	–	–	–	–	–	–
8102	–	–	–	–	–	–	–	–	–	–	–
Plt. Total	1051	390	327	417	901	424	569	91	5	14	11

TABLE 9. PLANT 8 DUST COLLECTOR URANIUM DISCHARGES, CY 1954 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
G3A-2	–	–	–	–	–	–	–	–	–	–
G8-1	–	–	–	–	–	–	–	–	–	–
G8-2	–	–	–	–	–	–	–	–	–	–
G8-3	–	–	–	–	–	–	–	–	–	–
G8-4	–	–	–	–	–	–	–	–	–	–
G8-7	–	–	–	–	–	–	–	–	–	–
G8N1-1000	–	–	–	–	–	–	–	–	–	–
G43-27	–	6.3	4.6	–	–	–	–	80.1	10.3	1.3
G43-29	–	–	–	–	–	5.1	–	0.7	–	0.5
G43-44C	–	–	–	–	–	–	–	–	–	–
6018	–	–	–	–	–	–	–	–	–	–
6019	–	–	–	–	–	–	–	–	–	–
8002	–	–	–	–	–	–	–	–	–	–
8021	1.3	–	–	–	–	–	–	–	–	–
8024	2.2	0.6	–	–	–	–	–	–	14.4	2.7
8035	–	–	–	–	–	–	–	0.4	–	3.6
8057	–	0.3	–	–	–	–	–	–	–	–
8083	–	–	–	–	–	–	–	–	–	–
8102	–	–	–	–	–	–	–	–	–	–
Plt. Total	3.5	7.2	4.6	0	0	5.1	0	81.2	24.7	8.1

TABLE 10. PLANT 9 DUST COLLECTOR URANIUM DISCHARGES, CY 1954 THROUGH CY-1984
(kg U)

DUST COLLECTOR	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
G9N1-1039	–	–	–	–	–	–	–	–	–	12
G9E2-400	–	–	–	–	–	–	–	–	–	12
G42-615	–	–	–	0.4	679	382	185	40	59	73
G42A-100	–	–	–	–	–	35	34	27.4	76	62
Plt. Total	0	0	0	0.4	679	417	219	67.4	135	159

TABLE 10. PLANT 9 DUST COLLECTOR URANIUM DISCHARGES, CY 1954 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
G9N1-1039	112	58.3	21.6	33.9	53.7	5.6	6.0	-	24	15	38
G9E2-400	10	-	1.9	3.0	4.8	0.5	0.5	-	-	-	-
G42-615	130	-	25	39.3	62.5	6.6	7.1	-	-	-	-
G42A-100	-	9.7	-	-	-	-	-	-	-	-	-
Plt. Total	252	68	48.5	76.2	121.0	12.7	13.6	0	24	15	38

TABLE 10. PLANT 9 DUST COLLECTOR URANIUM DISCHARGES, CY 1954 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
G9N1-1039	-	2.8	-	72	2.3	-	-	5.1	-	108
G9E2-400	-	-	-	-	-	-	-	-	-	1.2
G42-615	-	-	-	-	-	-	-	-	-	61.7
G42A-100	-	-	-	-	-	-	-	-	-	-
Plt. Total	0	2.8	0	72	2.3	0	0	5.1	0	170.9

TABLE 11. PILOT PLANT DUST COLLECTOR URANIUM DISCHARGES, CY 1951 THROUGH CY-1984
(kg U)

DUST COLLECTOR	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
G-1	–	–	–	–	–	–	–	–	–	–	–	–	–
G-2	–	–	–	–	–	–	–	–	–	–	–	–	–
G2-20	47	189	189	267	147	26	10	25	34	716	170	147	47
G6-93A	–	–	–	–	–	–	–	–	–	–	–	–	–
G37-5011	–	0.2	0.2	74	0.4	6	8	2	–	2	–	–	0.4
735-13-7041	–	–	–	–	–	–	–	–	–	–	–	–	1
735-13-7050	–	–	–	–	–	–	–	–	–	–	4	–	3
108843	–	–	–	–	–	–	–	–	–	–	–	27	0.4
Oxidn. Fce	–	–	–	–	–	–	–	–	–	–	–	–	–
Burnout[1]	4	15	15	4800	–	–	–	–	–	–	–	–	–
Hoffman[1]	–	0.2	0.2	–	–	–	–	–	–	–	–	–	–
Boildown[1]	–	0.1	0.1	–	–	–	–	–	–	–	–	–	–
Chip Furnace[1]	5	20.4	20.4	–	–	–	–	–	–	–	–	–	–
Plt. Total	60	224.9	224.9	5141	147.4	32	18	27	34	718	174	174	51.8

(1) Specific collectors were not identified in discharge reports. These designations were not used after 1954.

TABLE 11. PILOT PLANT DUST COLLECTOR URANIUM DISCHARGES, CY 1951 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
G-1	–	–	–	–	–	–	–	–	–	–	–
G-2	–	–	–	–	–	–	–	–	–	–	–
G2-20	10	–	13.9	9.1	2.8	2.8	–	–	–	–	–
G6-93A	–	–	–	–	–	–	–	–	–	–	–
G37-5011	–	1	–	–	–	–	–	–	–	–	–
735-13-7041	3	4	4.2	2.7	0.8	0.8	–	–	–	–	–
735-13-7050	–	5	–	–	–	–	–	–	–	–	–
108843	–	–	–	–	–	–	–	–	–	–	–
Oxidn. Fce	–	–	–	–	–	–	–	–	–	–	–
Plt. Total	13	10.	18.1	11.8	3.6	3.6	0	0	0	0	0

TABLE 11. PILOT PLANT DUST COLLECTOR URANIUM DISCHARGES, CY 1951 THROUGH CY-1984 (continued)
(kg U)

DUST COLLECTOR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
G-1	–	–	–	–	–	–	–	–	–	0.7
G-2	–	–	–	–	–	–	–	–	–	0.4
G2-20	–	–	–	–	–	–	–	–	–	–
G6-93A	–	–	–	–	–	–	–	–	–	–
G37-5011	–	–	–	–	–	2.6	–	–	–	–
735-13-7041	–	–	–	–	–	–	–	–	–	1.2
735-13-7050	–	–	0.1	–	–	–	–	–	–	0.4
108843	0.4	–	10.3	0.5	–	–	–	–	–	–
Oxidn. Fce	–	–	–	1.7	–	0.7	–	–	–	0.1
Plt. Total	0.4	0	10.4	2.2	0	3.3	0	0	0	2.8

TABLE 12. % U-235 IN DUST COLLECTOR STACK DISCHARGES

FISCAL YEAR	WEIGHTED % U-235
1984	0.81
1983	0.85
1982	0.41
1981	0.32
1980	0.42
1979	0.29
1978	0.91
1977	0.56
1976A(1)	0.20
1976	0.54
1975	0.53
1974	0.56
1973	0.68
1972	0.74
1971	0.71
1970	0.78
1969	0.86
1968	0.90
1967	0.84
1966	1.68
1965	0.82
1964	0.75
1963	0.85
1962	0.75
1961	0.86

TABLE 12. % U-235 IN DUST COLLECTOR STACK DISCHARGES (continued)

FISCAL YEAR	WEIGHTED % U-235
1960	0.73
1959	0.77
1958	0.72
1957	0.71
1956	0.52
1955	0.71
1954	0.63
1953	0.14
1952	-

(1) FY-1976A is the period of time from July 1, 1976 to September 30, 1976.

TABLE 13. NON-PRODUCTION SOURCES OF AIRBORNE URANIUM DISCHARGES

Graphite Burner

(1) Operating period: 11/1/65 to 9/14/84

(2) Estimated uranium discharge:

1965	1.2 kg
1966-1982	7 kg/yr
1983	2.4 kg
1984	6.4 kg

(3) U-235 content: 0.92%

Oil Burner

(1) Operating period: 3/31/62 to 6/15/79

(2) Estimated uranium discharge:

1962	20 kg
1963-1978	27 kg/yr
1979	15 kg

(3) U-235 content: 0.75%

Old Solid Waste Incinerator

(1) Operating period: 11/16/54 to 12/31/79

(2) Estimated uranium discharge:

1954	15 kg
1955-1968	118 kg/yr
1969	94 kg
1970-1979	71 kg/yr

(3) U-235 content: approximately 0.7%

TABLE 13. NON-PRODUCTION SOURCES OF AIRBORNE URANIUM DISCHARGES (continued)

New Solid Waste Incinerator

(1) Operating period: 1/2/80 to present

(2) Estimated uranium discharge:

1980	0.7 kg
1981	1.2 kg
1982	1.8 kg
1983	2.4 kg
1984	6.4 kg

(3) U-235 content: approximately 0.7

Liquid Organic Waste Incinerator

(1) Operating period: 4/1/83 to present

(2) Estimated uranium discharge:

1983	3 kg
1984	4 kg

(3) U-235 content: approximately 0.7%

TABLE 14. DISCHARGE OF URANIUM FROM FMPC WET SCRUBBERS

FISCAL[1] YEAR	URANIUM DISCHARGE kg	WEIGHTED % U-235
1984	38	0.91
1983	58	0.98
1982	37	0.95
1981	10	1.02
1980	11	0.95
1979	-	-
1978	-	-
1977	-	-
1976	-	-
1975	-	-
1974	-	-
1973	39	1.09
1972	-	-
1971	541	0.77
1970	666	0.88
1969	3123	0.90
1968	3082	0.83
1967	1790	0.83
1966	926	0.83

TABLE 14. DISCHARGE OF URANIUM FROM FMPC WET SCRUBBERS (continued)

FISCAL[1] YEAR	URANIUM DISCHARGE kg	WEIGHTED % U-235
1965	5810	0.82
1964	2865	0.79
1963	2171	0.86
1962	2304	0.75
1961	2371	0.87
1960	2604	0.75
1959	2100	0.76
1958	1650	0.72
1957	1575	0.71
1956	1442	0.71
1955	948	0.71
1954	217	0.71

(1) Scrubber uranium discharges on a calendar year basis could be obtained for only five years:

CALENDAR YEAR	URANIUM DISCHARGE kg	WEIGHTED % U-235
1984	38	0.90
1983	49	1.00
1982	39	0.95
1981	22	0.95
1980	20	0.98

TABLE 15. RADIONUCLIDES IN PLANT 8 SCRUBBER LIQUIDS.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g Sample	uCi/kg U
BOX FURNACE SCRUBBER		
Pu-239+240	1.2×10^{-5}	7.1×10^{1}
Pu-238	1.6×10^{-6}	9.5×10^{-1}
Np-237	2.5×10^{-6}	1.5
Th-234(1)	5.4×10^{-4}	3.2×10^{2}
Pa-234	3.0×10^{-7}	1.8×10^{-1}
Th-232	3.9×10^{-5}	2.3×10^{1}
Th-230	5.1×10^{-5}	3.0×10^{1}
Th-228	3.8×10^{-5}	2.3×10^{1}
Ra-228	8.9×10^{-7}	5.3×10^{-1}
Ra-226	1.8×10^{-6}	1.1
Cs-137	2.2×10^{-5}	1.3×10^{1}
Ru-106	$<1.0 \times 10^{-6}$	$<5.9 \times 10^{-1}$
Tc-99	1.2×10^{-4}	7.1×10^{1}
Sr-90	$<1.0 \times 10^{-5}$	<5.0

Scrubber liquid density: 1.0024
Uranium concentration: 1.69 gU/L
Isotopic composition, % by weight:

U-233	<0.001
U-234	<0.01
U-235	0.63
U-236	0.03
U-238	99.34

Uranium compound: U_3O_8

(1) Correctd to 12 noon on the day of sample collection.

TABLE 15. RADIONUCLIDES IN PLANT 8 SCRUBBER LIQUIDS. (continued)

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g Sample	uCi/kg U
ROTARY KILN SCRUBBER		
Pu-239+240	2.0×10^{-5}	3.0
Pu-238	2.2×10^{-6}	3.3×10^{-1}
Np-237	4.7×10^{-6}	7.0×10^{-1}
Th-234(1)	4.1×10^{-3}	6.1×10^{2}
Pa-234	1.4×10^{-6}	2.1×10^{-1}
Th-232	5.2×10^{-5}	7.7
Th-230	5.2×10^{-4}	7.7×10^{1}
Th-228	4.2×10^{-5}	6.2
Ra-228	1.5×10^{-6}	2.2×10^{-1}
Ra-226	8.3×10^{-7}	1.2×10^{-1}
Cs-137	4.4×10^{-6}	6.5×10^{-1}
Ru-106	$<9.8 \times 10^{-7}$	$<1.5 \times 10^{-1}$
Tc-99	2.6×10^{-4}	3.9×10^{1}
Sr-90	2.3×10^{-5}	3.4

Scrubber liquid density: 1.0226
Uranium concentration: 6.9 gU/L
Isotopic composition, % by weight:

U-233	<0.001
U-234	<0.01
U-235	0.92
U-236	0.05
U-238	99.03

Uranium compound: U_3O_8

(1) Correctd to 12 noon on the day of sample collection.

TABLE 15. RADIONUCLIDES IN PLANT 8 SCRUBER LIQUIDS. (continued)

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION	
	uCi/g Sample	uCi/kg U
NO. 1 OXIDATION FURNACE		
Pu-239+240	1.3×10^{-6}	3.6×10^{-2}
Pu-238	4.4×10^{-7}	1.2×10^{-2}
Np-237	1.3×10^{-6}	3.6×10^{-2}
Th-234(1)	3.4×10^{-3}	9.4×10^{1}
Pa-234	1.3×10^{-6}	3.6×10^{-2}
Th-232	3.7×10^{-5}	1.0
Th-230	4.2×10^{-5}	1.2
Th-228	1.3×10^{-4}	3.6
Ra-228	5.5×10^{-6}	1.5×10^{-1}
Ra-226	5.8×10^{-7}	1.6×10^{-2}
Cs-137	4.6×10^{-5}	1.3
Ru-106	$<9.8 \times 10^{-7}$	$<2.7 \times 10^{-2}$
Tc-99	2.1×10^{-4}	5.8
Sr-90	9.8×10^{-6}	2.7×10^{-1}

Scrubber liquid density: 1.0188
Uranium concentration: 36.8 g/L
Isotopic composition, % by weight:

U-233	<0.001
U-234	<0.01
U-235	0.22
U-236	<0.01
U-238	99.77

Uranium compound: U_3O_8

(1) Correctd to 12 noon on the day of sample collection.

TABLE 16-A. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-2. INLET DUCT.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
11.0	30.7
6.5	53.4
4.2	79.8
2.9	94.0
1.8	98.8
0.92	99.6
0.58	99.7
0.37	99.8

B. AMAD (2): 7.5 ± 2.0 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.84%
U-236	0.07%
U-238	99.09%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 16-B. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-2. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
12.0	35.1
7.8	61.0
5.1	80.1
3.4	89.6
2.2	93.6
1.15	95.7
0.67	97.0
0.45	98.6

B. AMAD [2]: 9.8 ± 2.3 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.82%
U-236	0.06%
U-238	99.11%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 16-C. TOTAL PARTICULATE DATA. PLANT 4 DUST COLLECTOR G4-2. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	27.3
20	54.2
10	81.8
7	86.2
5	88.7
4	91.3
3	93.5
2	95.6
1	97.1
0.6	97.5
0.4	97.8

B. MEDIAN SPHERICAL DIAMETER: 22.5 ± 2.8 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 75.9% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.84%
U-236	0.07%
U-238	99.09%

(1) Equivalent spherical diameter.

TABLE 17-A. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-5. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
11.0	27.8
6.9	35.4
4.5	44.9
3.1	71.0
1.9	88.5
1.0	96.3
0.51	98.2
0.40	99.6

B. AMAD [2]: 4.4 ± 1.9 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.88%
U-236	0.05%
U-238	99.06%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 17-B. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-5. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
12.0	30.3
7.1	45.4
4.9	58.2
3.3	68.7
2.1	78.0
1.1	89.1
0.65	93.5
0.43	96.6

B. AMAD [2]: 6.2 ± 4.4 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight[3]

U-233	<0.0010%
U-234	<0.01%
U-235	0.80%
U-236	0.05%
U-238	99.14%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.
(3) Insufficient uranium on impactor filters to run isotopic analysis. Isotopic composition given there is for a sample of collector bulk dust obtained during the sampling of the emission stack.

TABLE 17-C. TOTAL PARTICULATE DATA. PLANT 4 DUST COLLECTOR G4-5. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	2.0
20	22.6
15	37.8
10	59.8
7	78.0
5	86.1
4	89.7
3	92.7
2	96.3
1	98.8
0.6	99.6

B. MEDIAN SPHERICAL DIAMETER: 11.5 ± 2.2 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 71.1% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.80%
U-236	0.05%
U-238	99.14%

(1) Equivalent spherical diameter.

TABLE 18-A. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-7. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
9	6.0
5.9	13.2
3.9	19.1
2.6	30.4
1.7	60.7
0.91	84.9
0.5	94.8
0.32	98.4

B. AMAD [2]: 1.9 ± 3.8 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.88%
U-236	0.06%
U-238	99.05%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 18-B. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-7. EMISSION STACK.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
20	24.6
12.5	38.4
8.8	50.7
5.9	60.7
3.2	73.0
1.7	83.0
1.1	91.4
0.70	96.3

B. AMAD (2): 9.0 ± 5.6 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.93%
U-236	0.04%
U-238	99.02%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 18-C. TOTAL PARTICULATE DATA. PLANT 4 DUST COLLECTOR G4-7. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	10.0
20	38.1
15	53.2
10	66.5
7	73.5
5	77.9
4	81.5
3	86.5
2	91.0
1	98.0
0.6	99.1
0.4	99.6

B. MEDIAN SPHERICAL DIAMETER: 16.0 ± 4.7 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 50.8% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	1.11%
U-236	0.05%
U-238	98.82%

(1) Equivalent spherical diameter.

TABLE 19-A. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-12. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
11.0	38.8
6.9	74.7
4.5	90.7
3.0	96.0
1.9	98.2
0.97	99.0
0.59	99.4
0.39	99.6

B. AMAD [2]: 10.5 ± 2.3 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	1.76%
U-236	<0.01%
U-238	98.22%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 19-B. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-12. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
11.2	28.7
7.1	59.6
4.9	81.5
3.2	93.5
2.1	96.5
1.1	98.0
0.60	98.8
0.42	99.2

B. AMAD [2]: 8.0 ± 1.9 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.0010%
U-234	<0.01%
U-235	1.70%
U-236	0.03%
U-238	98.27%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 19-C. TOTAL PARTICULATE DATA. PLANT 4 DUST COLLECTOR G4-12 COLLECTOR BULK DUST.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
44	<0.1
20	13.2
15	23.8
10	40.0
7	54.0
5	68.2
4	77.6
3	86.0
2	93.8
1	97.4
0.6	98.8
0.4	99.6

B. MEDIAN SPHERICAL DIAMETER: 7.8 ± 2.4 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 75.1% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.0010%
U-234	<0.01%
U-235	1.78%
U-236	<0.01%
U-238	98.20%

(1) Equivalent spherical diameter.

TABLE 20-A. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-14. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
11.5	63.0
7.2	89.1
4.9	97.8
3.3	99.4
2.2	98.8
1.1	99.9
0.66	99.95
0.44	99.95

B. AMAD [2] [3]: 14 ± 2.1 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.20%
U-236	<0.01%
U-238	99.80%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.
(3) Estimated.

TABLE 20-B. URANIUM PARTICLE DATA. PLANT 4 DUST COLLECTOR G4-14. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
16	21
9.9	45
6.8	64.3
4.6	76.7
2.9	87.5
1.45	92.5
0.90	94.5
0.67	96.5

B. AMAD [2]: 9.0 ± 3.0 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.32%
U-236	0.01%
U-238	99.67%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 20-C. TOTAL PARTICULATE DATA. PLANT 4 DUST COLLECTOR G4-14. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	26.1
20	39.4
10	75.6
7	89.3
5	94.1
4	96.3
3	97.8
2	98.5
1	99.3

B. MEDIAN SPHERICAL DIAMETER: 14.7 ± 1.8 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 75.9% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.20%
U-236	<0.01%
U-238	99.80%

(1) Equivalent spherical diameter.

TABLE 21-A. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-249. INLET DUCT.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
12.0	40.4
7.0	70.2
4.8	86.8
3.2	94.6
2.0	97.1
1.0	98.2
0.61	98.9
0.42	99.4

B. AMAD (2): 10.3 ± 2.2 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	1.43%
U-236	0.02%
U-238	99.85%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 21-B. URANIUM PARTICLE DATA. PLANT 5 G5-249 DUST COLLECTOR. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
12.0	24.2
7.8	46.6
5.2	62.0
3.4	70.5
2.1	76.0
1.01	78.0
0.65	80.0
0.44	81.0

B. AMAD [2]: 6.7 ± 2.2 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.85%
U-236	0.05%
U-238	99.09%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 21-C. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-249. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	7.9
20	13.0
10	76.1
7	85.7
5	90.3
4	94.0
3	96.3
2	98.2
1	98.2
0.6	99.1
0.4	99.1

B. MEDIAN SPHERICAL DIAMETER: 13.5 ± 1.4 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 46.6% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.22%
U-236	<0.01%
U-238	99.77%

(1) Equivalent spherical diameter.

TABLE 22-A. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-250. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
13.0	62.7
7.9	86.6
5.2	96.2
3.6	98.8
2.3	99.6
1.2	99.8
0.70	99.8
0.47	99.8

B. AMAD [2]: 16.3 ± 2.0 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.32%
U-236	<0.01%
U-238	99.79%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 22-B. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-250. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
11.0	37.5
6.6	57.9
4.5	73.6
2.9	81.5
1.9	89.4
0.95	93.3
0.59	94.8
0.38	97.2

B. AMAD [2]: 8.3 ± 3.1 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight[3]

U-233	<0.001%
U-234	<0.01%
U-235	0.20%
U-236	<0.01%
U-238	99.85%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.
(3) Insufficient uranium on impactor filters to run isotopic analysis. Isotopic composition given there is for a sample of collector bulk dust obtained during the sampling of the emission stack.

TABLE 22-C. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-250. COLLECTOR BULK DUST.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
44	15.8
20	23.4
10	74.7
7	84.4
5	89.9
4	93.7
3	96.2
2	97.9
1	98.3
0.6	98.3
0.4	98.7

B. MEDIAN SPHERICAL DIAMETER: 14 ± 2 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 34.4% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.20%
U-236	0.01%
U-238	99.79%

(1) Equivalent spherical diameter.

TABLE 23-A. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-251. INLET DUCT.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
12.0	1.9
7.1	3.8
4.8	5.9
3.2	7.5
2.1	9.8
1.1	17.7
0.62	37.7
0.48	62.0

B. AMAD (2): 0.48 ± 8.8 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.27%
U-236	<0.01%
U-238	99.73%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 23-B. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-251. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
12.0	15.0
7.0	60.0
4.75	69.8
3.25	76.9
2.1	81.4
1.05	87.3
0.63	92.4
0.42	94.7

B. AMAD [2]: 7.8 ± 5.2 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight[3]

U-233	<0.001%
U-234	<0.01%
U-235	0.43%
U-236	0.01%
U-238	99.55%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.
(3) Insufficient uranium on impactor filters to run isotopic analysis. Isotopic composition given there is for a sample of collector bulk dust obtained during the sampling of the emission stack.

TABLE 23-C. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-251. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	2.0
20	4.9
10	19.6
9	73.5
7	94.1
5	94.2
2	95.1
1	96.1
0.5	96.5

B. MEDIAN SPHERICAL DIAMETER: 9.4 ± 1.1 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 3.7% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.43%
U-236	0.01%
U-238	99.55%

(1) Equivalent spherical diameter.

TABLE 24-A. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-253. INLET DUCT.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
11.0	32.8
7.0	72.5
4.8	77.3
3.2	81.9
2.0	90.3
1.0	94.6
0.62	97.5
0.42	98.7

B. AMAD (2): 9.0 ± 2.6 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.80%
U-236	0.06%
U-238	99.14%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 24-B. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-253. EMISSION STACK.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
12.0	1.3
7.0	3.3
4.8	5.9
3.3	12.2
2.0	18.3
1.0	35.2
0.63	60.4
0.42	97.9

B. AMAD (2): 0.72 ± 1.5 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.21%
U-236	<0.01%
U-238	99.79%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 24-C. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-253. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	52.6
25	59.2
20	64.0
15	73.9
10	85.8
7	92.3
5	95.8
3	98.3
2	99.5
1	99.8

B. MEDIAN SPHERICAL DIAMETER: >44 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 1.6% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.39%
U-236	<0.01%
U-238	99.60%

(1) Equivalent spherical diameter.

TABLE 25-A. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-254. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
10.0	37.0
6.1	59.8
4.1	76.2
2.8	87.4
1.7	95.1
0.89	99.2
0.55	99.8
0.37	99.9

B. AMAD [2]: 7.6 ± 2.5 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.0010%
U-234	<0.01%
U-235	0.87%
U-236	0.05%
U-238	99.07%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 25-B. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-254. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
11.0	14.2
6.8	34.9
4.5	58.4
3.0	71.7
1.9	81.3
0.98	89.7
0.59	95.3
0.40	98.5

B. AMAD [2]: 5.2 ± 3.0 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.44%
U-236	0.02%
U-238	99.54%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 25-C. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-254. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	34.7
25	38.0
20	47.1
18	66.7
15	94.8
10	99.3
5	99.3
1	>99.3

B. MEDIAN SPHERICAL DIAMETER: 19.5 ± 3.7 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 2.2% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.28%
U-236	0.01%
U-238	99.71%

(1) Equivalent spherical diameter.

TABLE 26-A. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-256. INLET DUCT.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
11.0	27.9
7.1	55.0
4.8	75.3
3.2	85.5
2.1	90.7
1.0	93.7
0.63	95.4
0.42	97.3

B. AMAD (2) (3): 7.8 ± 2.2 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight(3)

U-233	<0.001%
U-234	<0.01%
U-235	0.27%
U-236	0.01%
U-238	99.72%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.
(3) Insufficient uranium on impactor filters to run isotopic analysis. Isotopic composition given here is for a sample of collector bulk dust obtained during the sampling of the emission stack.

TABLE 26-B. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-256. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
11.0	15.3
6.9	48.1
4.2	56.3
2.9	61.8
1.8	71.1
0.91	83.7
0.59	93.5
0.38	97.3

B. AMAD [2]: 6.5 ± 1.7 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.51%
U-236	0.02%
U-238	99.46%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 26-C. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-256. COLLECTOR BULK DUST.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
44	20.3
25	29.1
20	76.1
18	82.5
15	88.0
10	93.6
5	94.4
1	98.0
0.5	99.2

B. MEDIAN SPHERICAL DIAMETER: 23 ± 1.4 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 2.5% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.27%
U-236	0.01%
U-238	99.72%

(1) Equivalent spherical diameter.

TABLE 27-A. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-260. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
11	24.2
6.6	53.1
4.4	73
2.9	85
1.9	92.8
0.95	98
0.58	98.7
0.38	98.8

B. AMAD [2]: 7.0 ± 2.3 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.26%
U-236	<0.01%
U-238	99.73%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 27-B. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-260. EMISSION STACK.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
14.0	5.0
8.9	9.5
6.0	13.4
4.1	15.9
2.6	16.9
1.3	46.3
0.80	68.1
0.55	91.0

B. AMAD (2): 1.1 ± 1.8 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight(3)

U-233	<0.001%
U-234	<0.01%
U-235	0.20%
U-236	<0.01%
U-238	99.80%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.
(3) Insufficient uranium on impactor filters to run isotopic analysis. Isotopic composition given there is for a sample of collector bulk dust obtained during the sampling of the emission stack.

TABLE 27-C. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-260. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	27.2
20	37.4
10	57.0
7	62.9
5	69.8
4	76.8
3	83.3
2	91.1
1	98.9
0.6	99.4
0.4	99.6

B. MEDIAN SPHERICAL DIAMETER: 12.3 ± 4.4 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 49.5% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.20%
U-236	<0.01%
U-238	99.80%

(1) Equivalent spherical diameter.

TABLE 28-A. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-261. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
12	44.5
7.2	73
5.1	87
3.5	92.5
2.2	96.5
1.2	99
0.68	99
0.46	99.5

B. AMAD [2]: 10.8 ± 1.4 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.21%
U-236	<0.01%
U-238	99.78%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 28-B. URANIUM PARTICLE DATA. PLANT 5 DUST COLLECTOR G5-261. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
11	21.5
6.8	55.5
4.4	67.5
3.1	87
2.0	88.5
1.0	96
0.6	97
0.4	98.5

B. AMAD [2]: 6.6 ± 1.2 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.25%
U-236	<0.01%
U-238	99.74%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 28-C. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-261. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	0.1
20	2
10	2
7	2.5
5	9
4	22.5
3	41
2	67
1	90
0.6	95.5
0.4	97.5

B. MEDIAN SPHERICAL DIAMETER: 2.5 ± 1.8 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 75.12% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.21%
U-236	<0.01%
U-238	99.79%

(1) Equivalent spherical diameter.

TABLE 29-A. URANIUM PARTICLE DATA. PLANT 8 DUST COLLECTOR G43-27. INLET DUCT.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
13	23.6
7.2	48.8
5.2	68.2
3.5	78.5
2.2	88.0
1.1	94.9
0.68	97.2
0.45	98.4

B. AMAD [2]: 7.4 ± 3.1 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.86%
U-236	0.05%
U-238	99.09%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 29-B. URANIUM PARTICLE DATA. PLANT 8 DUST COLLECTOR G43-27. EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
13.0	20.0
7.8	55.0
5.1	76.6
3.5	86.6
2.2	93.4
1.2	98.5
0.70	99.6
0.48	99.8

B. AMAD [2]: 8.8 ± 2.3 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.87%
U-236	0.05%
U-238	99.08%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 29-C. TOTAL PARTICULATE DATA. PLANT 8 DUST COLLECTOR G43-27. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
44	25.2
20	29.7
10	49.9
8	57.5
6	67.4
5	73.4
4	80.3
3	86.5
2	93.6
1	99.3
0.6	99.7

B. MEDIAN SPHERICAL DIAMETER: 9.8 ± 2.8 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 10.9% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.93%
U-236	0.05%
U-238	99.01%

(1) Equivalent spherical diameter.

TABLE 30-A. URANIUM PARTICLE DATA. PLANT 9 DUST COLLECTOR G9N1-1039. INLET DUCT.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
10.5	6.3
6.5	36.8
4.3	59.3
2.9	82.1
1.8	90.3
0.92	94.9
0.56	98.5
0.38	99.7

B. AMAD (2): 5.0 ± 2.0 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.95%
U-236	0.05%
U-238	98.99%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.

TABLE 30-B. URANIUM PARTICLE DATA. PLANT 9 DUST COLLECTOR G9N1-1039 EMISSION STACK.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
11	9.3
6.4	20.6
4.5	31.9
2.9	41.2
1.8	48
0.95	56.8
0.56	77.8
0.39	91.5

B. AMAD [2]: 1.3 ± 2.7 MICRONS.

C. ISOTOPIC COMPOSITION: Percent by weight[3]

U-233	<0.001%
U-234	<0.01%
U-235	0.93%
U-236	0.05%
U-238	99.01%

(1) Equivalent aerodynamic diameter.
(2) Activity median aerodynamic diameter ± one standard deviation.
(3) Insufficient uranium on impactor filters to run isotopic analysis. Isotopic composition given here is for a sample of collector bulk dust obtained immediately after sampling of the emission stack.

TABLE 30-C. TOTAL PARTICULATE DATA. PLANT 4 COLLECTOR BULK DUST DUST COLLECTOR G9-1039.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
44	16.2
20	33.4
15	43.9
10	56.8
7	64.8
5	71.9
4	77.4
3	84.4
2	91.6
1	97.9
0.5	99.2

B. MEDIAN SPHERICAL DIAMETER 12.0 ± 4.1 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 55.84% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.93%
U-236	0.05%
U-238	99.01%

(1) Equivalent spherical diameter.

TABLE 31. TOTAL PARTICULATE DATA. PLANT 1 DUST COLLECTOR G2-1. COLLECTOR BULK DUST.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
>44	30.4
25	39.4
20	45.0
15	52.7
10	68.9
8	79.8
6	93.0
4	96.8
2	99.3
1	99.6
0.6	99.8

B. MEDIAN SPHERICAL DIAMETER: 16.8 ± 2.3 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 70.76% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.95%
U-236	0.01%
U-238	99.03%

(1) Equivalent spherical diameter.

TABLE 32. TOTAL PARTICULATE DATA. PLANT 1 DUST COLLECTOR G2-64. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	15.8
25	18.4
15	26.8
10	43.0
8	51.6
6	63.4
4	77.2
3	85.6
2	93.8
1	99.2
0.6	99.4

B. MEDIAN SPHERICAL DIAMETER: 8.2 ± 2.6 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 16.01% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.71%
U-236	0.01%
U-238	99.27%

(1) Equivalent spherical diameter.

TABLE 33. TOTAL PARTICULATE DATA. PLANT 1 DUST COLLECTOR G2-76. COLLECTOR BULK DUST.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
>44	35.7
30	42.2
25	48.0
20	60.8
15	66.2
10	86.8
8	91.6
6	96.0
4	98.6
2	99.4
1	99.6
0.6	99.8

B. MEDIAN SPHERICAL DIAMETER: 24.0 ± 2.2 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 2.77% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.84%
U-236	0.02%
U-238	99.13%

(1) Equivalent spherical diameter.

TABLE 34. TOTAL PARTICULATE DATA. PLANT 1 DUST COLLECTOR G2-172. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	26.4
25	36.0
20	44.8
15	58.0
10	77.8
8	85.2
6	90.6
4	95.4
2	99.2
1	99.6
0.6	99.8

B. MEDIAN SPHERICAL DIAMETER: 18.0 ± 2.2 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 23.84% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.67%
U-236	0.02%
U-238	99.30%

(1) Equivalent spherical diameter.

TABLE 35. TOTAL PARTICULATE DATA. PLANT 1 DUST COLLECTOR G2-235. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	12.4
25	23.3
20	31.2
15	43.9
10	57.5
8	62.8
6	70.2
4	79.9
2	93.4
1	99.4
0.6	99.6

B. MEDIAN SPHERICAL DIAMETER: 12.6 ± 3.9 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 62.56% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	0.02%
U-235	3.43%
U-236	0.04%
U-238	96.51%

(1) Equivalent spherical diameter.

TABLE 36. TOTAL PARTICULATE DATA. PLANT 4 DUST COLLECTOR G4-1. COLLECTOR BULK DUST.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
>44	7.7
25	14.4
20	21.7
15	38.2
10	64.6
8	70.6
6	77.8
4	89.0
2	97.5
1	99.0
0.6	99.6

B. MEDIAN SPHERICAL DIAMETER: 13.0 ± 2.8 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 73.43% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.83%
U-236	0.06%
U-238	99.10%

(1) Equivalent spherical diameter.

TABLE 37. TOTAL PARTICULATE DATA. PLANT 4 DUST COLLECTOR G4-4. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	0.3
20	25.0
15	37.2
10	53.6
8	58.4
6	63.4
4	75.0
3	79.2
2	88.6
1	98.6
0.6	99.2

B. MEDIAN SPHERICAL DIAMETER: 11.0 ± 4.4 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 74.60% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.51%
U-236	0.02%
U-238	99.46%

(1) Equivalent spherical diameter.

TABLE 38. TOTAL PARTICULATE DATA. PLANT 4 DUST COLLECTOR G4-13. COLLECTOR BULK DUST.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
>44	6.0
25	13.0
20	19.2
15	30.4
10	44.8
8	49.6
6	56.6
4	70.8
3	78.6
2	89.0
1	98.6
0.6	99.5

B. MEDIAN SPHERICAL DIAMETER: 7.9 ± 3.3 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 81.72% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.90%
U-236	0.02%
U-238	99.07%

(1) Equivalent spherical diameter.

TABLE 39. TOTAL PARTICULATE DATA. PLANT 4 DUST COLLECTOR G4-15. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	1.8
20	4.0
15	5.0
10	12.2
8	22.4
6	50.6
4	79.4
3	88.0
2	93.4
1	97.0
0.6	99.2

B. MEDIAN SPHERICAL DIAMETER: 6.1 ± 1.7 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 73.51% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.84%
U-236	0.07%
U-238	99.08%

(1) Equivalent spherical diameter.

TABLE 40. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G2-67. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	31.0
35	32.6
30	40.0
25	67.5
20	89.6
15	95.4
10	95.4
8	95.4
6	96.6
5	96.6
4	98.0
3	98.5
2	99.2
1	99.8

B. MEDIAN SPHERICAL DIAMETER: 28.4 ± 1.4 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 2.32% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.81%
U-236	0.05%
U-238	99.13%

(1) Equivalent spherical diameter.

TABLE 41. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-247. COLLECTOR BULK DUST.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
>44	43.8
30	48.0
25	57.3
20	82.0
15	96.7
8	98.0
6	98.4
4	98.8
2	99.5
1	99.8

B. MEDIAN SPHERICAL DIAMETER: 29.0 ± 1.5 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 1.39% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.78%
U-236	0.05%
U-238	99.17%

(1) Equivalent spherical diameter.

TABLE 42. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-248. COLLECTOR BULK DUST.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
>44	33.8
30	36.6
25	39.6
20	49.8
15	80.2
12	93.4
6	94.8
4	96.0
2	98.0
1	99.4
0.8	99.8

B. MEDIAN SPHERICAL DIAMETER: 19.8 ± 1.4 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 1.47% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.21%
U-236	<0.01%
U-238	99.79%

(1) Equivalent spherical diameter.

TABLE 43. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5-262. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] [2] (MICRONS)	% GREATER THAN STATED SIZE
>44	88.2

B. MEDIAN SPHERICAL DIAMETER: >44 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 0.11% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.25%
U-236	<0.01%
U-238	99.74%

(1) Equivalent spherical diameter.

(2) Difficulties encountered in analysis. Dust collector G2-262 serves a shop in which clean graphite is machined. The pure graphite particles are transparent to X-rays.

TABLE 44. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5A-100. COLLECTOR BULK DUST.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
>44	29.8
25	38.4
20	47.0
15	59.6
10	72.4
8	76.0
6	79.6
4	87.4
2	96.0
1	99.3
0.6	99.8

B. MEDIAN SPHERICAL DIAMETER: 18.8 ± 4.1 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 5.15% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.31%
U-236	0.01%
U-238	99.68%

(1) Equivalent spherical diameter.

TABLE 45. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR G5A-101. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	6.0
25	7.0
20	17.3
15	87.3
10	93.9
8	94.2
5	94.8
4	97.4
2	99.6
1	99.8

B. MEDIAN SPHERICAL DIAMETER: 18.5 ± 1.2 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 6.19% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.22%
U-236	<0.01%
U-238	99.77%

(1) Equivalent spherical diameter.

TABLE 46. TOTAL PARTICULATE DATA. PLANT 5 DUST COLLECTOR BLDG. 55. COLLECTOR BULK DUST.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
>44	19.2
30	22.0
25	25.7
20	39.4
15	85.5
10	96.0
8	96.2
6	96.4
4	96.6
2	98.6
1	99.6
0.6	99.8

B. MEDIAN SPHERICAL DIAMETER: 28.8 ± 1.2 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 2.08% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.21%
U-236	<0.01%
U-238	99.78%

(1) Equivalent spherical diameter.

TABLE 47. TOTAL PARTICULATE DATA. PLANT 8 DUST COLLECTOR G43-29. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	1.8
20	7.0
15	16.8
10	32.8
8	42.4
6	55.2
4	75.6
3	86.0
2	96.4
1	99.6
0.6	99.8

B. MEDIAN SPHERICAL DIAMETER: 6.7 ± 2.2 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 68.87% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.91%
U-236	0.05%
U-238	99.03%

(1) Equivalent spherical diameter.

TABLE 48. TOTAL PARTICULATE DATA. PLANT 8 DUST COLLECTOR 8035. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	15.0
25	18.4
20	22.2
15	28.4
10	41.6
8	49.0
6	60.5
4	77.6
3	86.6
2	92.5
1	97.8
0.6	99.0
0.4	99.6

B. MEDIAN SPHERICAL DIAMETER: 7.9 ± 2.5 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 53.83% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.42%
U-236	0.02%
U-238	99.56%

(1) Equivalent spherical diameter.

TABLE 49. TOTAL PARTICULATE DATA. PILOT PLANT DUST COLLECTOR G-1. COLLECTOR BULK DUST.

A.

PARTICLE SIZE(1) (MICRONS)	% GREATER THAN STATED SIZE
>44	0.4
20	6.0
15	19.6
10	50.0
8	67.4
6	82.4
4	93.0
3	95.8
2	97.6
1	99.6
0.6	99.8

B. MEDIAN SPHERICAL DIAMETER: 10.0 ± 1.9 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 75.24% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.78%
U-236	<0.01%
U-238	99.27%

(1) Equivalent spherical diameter.

TABLE 50. TOTAL PARTICULATE DATA. PILOT PLANT DUST COLLECTOR G-2. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	0.2
20	3.4
15	11.6
10	39.5
8	56.4
6	65.6
4	89.6
3	93.0
2	95.4
1	97.0
0.6	97.6
0.4	98.6

B. MEDIAN SPHERICAL DIAMETER: 8.7 ± 1.9 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 75.06% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.74%
U-236	<0.01%
U-238	99.25%

(1) Equivalent spherical diameter.

TABLE 51. TOTAL PARTICULATE DATA. PILOT PLANT DUST COLLECTOR 735-13-7050. COLLECTOR BULK DUST.

A.

PARTICLE SIZE[1] (MICRONS)	% GREATER THAN STATED SIZE
>44	72.4
30	76.3
25	80.7
20	86.2
15	91.7
10	94.8
8	95.2
6	95.3
4	96.7
2	98.6
1	99.6
0.6	99.8

B. MEDIAN SPHERICAL DIAMETER: >44 MICRONS.

C. PERCENT URANIUM IN COLLECTOR BULK DUST: 2.43% (as U)

D. ISOTOPIC COMPOSITION: Percent by weight

U-233	<0.001%
U-234	<0.01%
U-235	0.62%
U-236	<0.01%
U-238	99.37%

(1) Equivalent spherical diameter.

TABLE 52. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 1 DUST COLLECTOR G2-1.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	7.3×10^{-5}	1.0×10^{-1}
Pu-238	7.8×10^{-6}	1.1×10^{-2}
Np-237	3.6×10^{-5}	5.1×10^{-2}
Th-234(1)	3.1×10^{-1}	4.4×10^{2}
Pa-234m	2.7×10^{-1}	3.8×10^{2}
Th-232	8.7×10^{-5}	1.2×10^{-2}
Th-230	1.6×10^{-4}	2.3×10^{-1}
Th-228	5.6×10^{-5}	7.9×10^{-2}
Ra-228	8.7×10^{-6}	1.2×10^{-2}
Ra-226	6.2×10^{-6}	8.8×10^{-3}
Cs-137	2.1×10^{-5}	3.0×10^{-2}
Ru-106	$<2.0 \times 10^{-4}$	$<2.8 \times 10^{-1}$
Tc-99	7.8×10^{-4}	1.1
Sr-90	$<4.0 \times 10^{-6}$	$<5.7 \times 10^{-3}$

Uranium in bulk dust, weight %, sample basis: 70.76

Uranium compound: UF_4 (1984), U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 53. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 1 DUST COLLECTOR G2-64.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	3.5×10^{-2}	2.2×10^{2}
Pu-238	1.4×10^{-3}	8.7
Np-237	1.9×10^{-3}	1.2×10^{1}
Th-234(1)	6.1×10^{-2}	3.8×10^{2}
Pa-234m	5.3×10^{-2}	3.3×10^{2}
Th-232	3.1×10^{-3}	1.9×10^{1}
Th-230	5.9×10^{-1}	3.6×10^{3}
Th-228	1.4×10^{-3}	8.7
Ra-228	1.7×10^{-3}	1.1×10^{1}
Ra-226	6.3×10^{-3}	3.9×10^{1}
Cs-137	2.0×10^{-3}	1.2×10^{1}
Ru-106	$<6.0 \times 10^{-4}$	<3.7
Tc-99	8.9×10^{-3}	5.6×10^{1}
Sr-90	3.7×10^{-4}	2.3

Uranium in bulk dust, weight %, sample basis: 16.01

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 54. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 1 DUST COLLECTOR G2-76.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.7×10^{-4}	6.1
Pu-238	1.6×10^{-5}	5.8×10^{-1}
Np-237	2.2×10^{-5}	7.9×10^{-1}
Th-234(1)	2.7×10^{-2}	9.7×10^{2}
Pa-234m	1.7×10^{-2}	6.1×10^{2}
Th-232	3.9×10^{-5}	1.4
Th-230	8.2×10^{-4}	3.0×10^{1}
Th-228	4.9×10^{-5}	1.8
Ra-228	2.2×10^{-5}	7.9
Ra-226	5.5×10^{-5}	2.0
Cs-137	8.3×10^{-4}	3.0×10^{1}
Ru-106	$<2.0 \times 10^{-4}$	<7.2
Tc-99	2.2×10^{-4}	7.9
Sr-90	6.6×10^{-4}	2.4×10^{1}

Uranium in bulk dust, weight %, sample basis: 2.77

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 55. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 1 DUST COLLECTOR G2-172.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	3.8×10^{-4}	1.6
Pu-238	6.9×10^{-5}	2.9×10^{-1}
Np-237	7.9×10^{-5}	3.3×10^{-1}
Th-234(1)	1.5×10^{-1}	6.3×10^{2}
Pa-234m	9.8×10^{-2}	4.1×10^{2}
Th-232	2.1×10^{-3}	8.8
Th-230	6.3×10^{-3}	2.6×10^{1}
Th-228	1.3×10^{-3}	5.5
Ra-228	1.3×10^{-3}	5.5
Ra-226	8.4×10^{-4}	3.5
Cs-137	7.4×10^{-6}	3.1×10^{-2}
Ru-106	$<3.0 \times 10^{-4}$	<1.3
Tc-99	1.2×10^{-1}	5.0×10^{2}
Sr-90	$<1.0 \times 10^{-5}$	$<4.2 \times 10^{-2}$

Uranium in bulk dust, weight %, sample basis: 23.84

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 56. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 1 DUST COLLECTOR G2-235.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.1×10^{-4}	1.8×10^{-1}
Pu-238	6.7×10^{-5}	1.1×10^{-1}
Np-237	4.8×10^{-5}	7.6×10^{-2}
Th-234(1)	3.1×10^{-1}	5.0×10^{2}
Pa-234m	2.2×10^{-1}	3.5×10^{2}
Th-232	2.0×10^{-4}	3.2×10^{-1}
Th-230	5.8×10^{-3}	9.3×10^{1}
Th-228	8.3×10^{-4}	1.3×10^{1}
Ra-228	7.8×10^{-5}	1.2×10^{-1}
Ra-226	3.1×10^{-4}	5.0×10^{-1}
Cs-137	1.4×10^{-4}	2.2×10^{-1}
Ru-106	$<5.0 \times 10^{-4}$	$<8.0 \times 10^{-1}$
Tc-99	3.4×10^{-3}	5.4×10^{1}
Sr-90	1.9×10^{-4}	3.0×10^{-1}

Uranium in bulk dust, weight %, sample basis: 62.56

Uranium compound: UO_2, U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 57. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 1 DUST COLLECTOR G4-1.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	2.2×10^{-4}	3.0×10^{-1}
Pu-238	2.1×10^{-5}	2.8×10^{-2}
Np-237	1.6×10^{-4}	2.2×10^{-1}
Th-234(1)	5.3×10^{-1}	7.2×10^{2}
Pa-234m	3.2×10^{-1}	4.4×10^{2}
Th-232	7.2×10^{-5}	9.8×10^{-2}
Th-230	2.2×10^{-4}	3.0×10^{-1}
Th-228	2.0×10^{-4}	2.7×10^{-1}
Ra-228	1.3×10^{-5}	1.8×10^{-2}
Ra-226	1.2×10^{-4}	1.6×10^{-1}
Cs-137	1.2×10^{-3}	1.6×10^{1}
Ru-106	$<2.0 \times 10^{-4}$	$<2.7 \times 10^{-1}$
Tc-99	4.3×10^{-2}	5.8×10^{1}
Sr-90	9.0×10^{-4}	1.2

Uranium in bulk dust, weight %, sample basis: 73.43

Uranium compound: UO_3

(1) Corrected to 12 noon on the day of sample collection.

TABLE 58. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 4 DUST COLLECTOR G4-2.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	4.1×10^{-5}	5.4×10^{-2}
Pu-238	4.8×10^{-6}	6.3×10^{-3}
Np-237	7.8×10^{-5}	1.0×10^{-1}
Th-234(1)	2.1×10^{-1}	2.8×10^{2}
Pa-234m	2.0×10^{-1}	2.6×10^{2}
Th-232	4.6×10^{-5}	6.1×10^{-2}
Th-230	6.8×10^{-5}	9.0×10^{-2}
Th-228	4.0×10^{-5}	5.3×10^{-2}
Ra-228	2.0×10^{-6}	2.6×10^{-3}
Ra-226	2.8×10^{-6}	3.7×10^{-3}
Cs-137	2.0×10^{-5}	2.6×10^{-2}
Ru-106(2)	6.4×10^{-5}	8.4×10^{-2}
Tc-99	6.2×10^{-2}	8.2×10^{1}
Sr-90	5.3×10^{-5}	7.0×10^{-2}

Uranium in bulk dust, weight %, sample basis: 75.86

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

(2) Ru-106 determined by radiochemical analyses; all other radionuclides determined by gamma spectroscopy.

TABLE 59. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 4 DUST COLLECTOR G4-4.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.4×10^{-4}	1.9×10^{-1}
Pu-238	1.3×10^{-5}	1.7×10^{-2}
Np-237	4.8×10^{-5}	6.4×10^{-2}
Th-234(1)	4.0×10^{-1}	5.4×10^{2}
Pa-234m	2.7×10^{-1}	3.6×10^{2}
Th-232	1.77×10^{-1}	3.6×10^{2}
Th-230	3.1×10^{-4}	4.2×10^{-1}
Th-228	1.9×10^{-4}	2.5×10^{-1}
Ra-228	5.4×10^{-6}	7.2×10^{-3}
Ra-226	3.8×10^{-6}	5.1×10^{-3}
Cs-137	2.4×10^{-5}	3.2×10^{-2}
Ru-106	$<4.0 \times 10^{-4}$	$<5.4 \times 10^{-1}$
Tc-99	3.9×10^{-2}	5.2×10^{1}
Sr-90	3.3×10^{-5}	4.4×10^{-2}

Uranium in bulk dust, weight %, sample basis: 74.60

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

TABLE 60. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 4 DUST COLLECTOR G4-5.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	7.5×10^{-5}	1.1×10^{-1}
Pu-238	1.3×10^{-5}	1.8×10^{-2}
Np-237	1.0×10^{-4}	1.4×10^{-1}
Th-234(1)	4.3×10^{-1}	6.0×10^{2}
Pa-234m	2.9×10^{-1}	4.1×10^{2}
Th-232	5.5×10^{-5}	7.7×10^{-2}
Th-230	2.3×10^{-4}	3.2×10^{-1}
Th-228	2.1×10^{-4}	3.0×10^{-1}
Ra-228	1.1×10^{-5}	1.5×10^{-2}
Ra-226	5.9×10^{-6}	8.2×10^{-3}
Cs-137	2.0×10^{-4}	2.8×10^{-1}
Ru-106	$<2.0 \times 10^{-4}$	$<2.8 \times 10^{-1}$
Tc-99	6.9×10^{-2}	9.7×10^{1}
Sr-90	1.4×10^{-4}	2.0×10^{-1}

Uranium in bulk dust, weight %, sample basis: 71.10

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

TABLE 61. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 4 DUST COLLECTOR G4-7.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	3.2×10^{-4}	6.3×10^{-1}
Pu-238	2.4×10^{-5}	4.7×10^{-2}
Np-237	7.7×10^{-5}	1.5×10^{-1}
Th-234(1)	3.1×10^{-1}	6.1×10^{2}
Pa-234m	2.1×10^{-1}	4.1×10^{2}
Th-232	8.5×10^{-5}	1.7×10^{-1}
Th-230	1.4×10^{-4}	2.8×10^{-1}
Th-228	1.6×10^{-4}	3.2×10^{-1}
Ra-228	2.1×10^{-6}	4.1×10^{-3}
Ra-226	2.4×10^{-6}	4.7×10^{-3}
Cs-137	3.4×10^{-5}	6.7×10^{-2}
Ru-106	$<6.0 \times 10^{-4}$	<1.2
Tc-99	5.4×10^{-2}	1.1×10^{2}
Sr-90	1.4×10^{-5}	2.8×10^{-2}

Uranium in bulk dust, weight %, sample basis: 50.83

Uranium compound: UO_2

(1) Corrected to 12 noon on the day of sample collection.

TABLE 62. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 4 DUST COLLECTOR G4-12.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.0×10^{-5}	1.3×10^{-2}
Pu-238	1.7×10^{-6}	2.3×10^{-3}
Np-237	2.6×10^{-6}	3.5×10^{-3}
Th-234(1)	2.2×10^{-1}	2.9×10^{2}
Pa-234m	1.9×10^{-1}	2.5×10^{2}
Th-232	2.6×10^{-5}	3.5×10^{-2}
Th-230	3.9×10^{-5}	5.2×10^{-2}
Th-228	3.7×10^{-5}	4.9×10^{-2}
Ra-228	2.0×10^{-6}	2.7×10^{-3}
Ra-226	9.1×10^{-7}	1.2×10^{-3}
Cs-137	7.3×10^{-5}	9.7×10^{-2}
Ru-106	$<1.0 \times 10^{-4}$	$<1.3 \times 10^{-1}$
Tc-99	1.6×10^{-3}	2.1
Sr-90	$<5.0 \times 10^{-6}$	6.7×10^{-3}

Uranium in bulk dust, weight %, sample basis: 75.12

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

TABLE 63. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 4 DUST COLLECTOR G4-13.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	3.9×10^{-5}	4.8×10^{-2}
Pu-238	7.0×10^{-6}	8.6×10^{-3}
Np-237	1.4×10^{-4}	1.7×10^{-1}
Th-234(1)	6.4×10^{-1}	7.8×10^{2}
Pa-234m	6.5×10^{-1}	8.0×10^{2}
Th-232	1.8×10^{-4}	2.2×10^{-1}
Th-230	2.5×10^{-4}	3.1×10^{-1}
Th-228	2.7×10^{-4}	3.3×10^{-1}
Ra-228	4.3×10^{-6}	5.3×10^{-3}
Ra-226	1.1×10^{-5}	1.3×10^{-2}
Cs-137	5.1×10^{-5}	6.2×10^{-2}
Ru-106	$<7.0 \times 10^{-4}$	$<8.6 \times 10^{-1}$
Tc-99	7.6×10^{-2}	9.3×10^{1}
Sr-90	2.6×10^{-5}	3.2×10^{-2}

Uranium in bulk dust, weight %, sample basis: 81.72

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 64. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 4 DUST COLLECTOR G4-14.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	7.6×10^{-7}	1.0×10^{-3}
Pu-238	2.7×10^{-6}	3.6×10^{-3}
Np-237	5.3×10^{-6}	7.0×10^{-3}
Th-234(1)	5.5×10^{-1}	7.3×10^{2}
Pa-234m	2.9×10^{-1}	3.8×10^{2}
Th-232	5.8×10^{-5}	7.7×10^{-2}
Th-230	1.0×10^{-4}	1.3×10^{-1}
Th-228	2.5×10^{-5}	3.3×10^{-2}
Ra-228	3.3×10^{-6}	4.4×10^{-3}
Ra-226	2.1×10^{-6}	2.8×10^{-3}
Cs-137	2.9×10^{-5}	3.8×10^{-2}
Ru-106	$<2.0 \times 10^{-4}$	$<2.6 \times 10^{-1}$
Tc-99	3.5×10^{-5}	4.6×10^{-2}
Sr-90	$<1.0 \times 10^{-5}$	1.3×10^{-2}

Uranium in bulk dust, weight %, sample basis: 75.76

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

TABLE 65. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 4 DUST COLLECTOR G4-15.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	3.4×10^{-4}	4.6×10^{-1}
Pu-238	2.9×10^{-5}	3.9×10^{-2}
Np-237	6.5×10^{-5}	8.8×10^{-2}
Th-234(1)	5.3×10^{-1}	7.2×10^{2}
Pa-234m	2.8×10^{-1}	3.8×10^{2}
Th-232	1.2×10^{-4}	1.6×10^{-1}
Th-230	4.0×10^{-4}	5.4×10^{-1}
Th-228	1.6×10^{-4}	2.2×10^{-1}
Ra-228	3.7×10^{-6}	5.0×10^{-3}
Ra-226	1.1×10^{-5}	1.5×10^{-2}
Cs-137	1.5×10^{-5}	2.0×10^{-2}
Ru-106	$<3.0 \times 10^{-4}$	$<4.1 \times 10^{-1}$
Tc-99	3.9×10^{-3}	5.3×10^{1}
Sr-90	$<1.0 \times 10^{-5}$	$<1.4 \times 10^{-2}$

Uranium in bulk dust, weight %, sample basis: 73.51

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

TABLE 66. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G2-67.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.2×10^{-4}	5.2
Pu-238	1.1×10^{-5}	4.7×10^{-1}
Np-237	3.4×10^{-5}	1.5
Th-234(1)	4.6×10^{-2}	2.0×10^{3}
Pa-234m	2.6×10^{-2}	1.1×10^{3}
Th-232	8.3×10^{-5}	3.6
Th-230	2.5×10^{-4}	1.1×10^{1}
Th-228	2.2×10^{-4}	9.5
Ra-228	4.2×10^{-5}	1.8
Ra-226	4.8×10^{-6}	2.1×10^{-1}
Cs-137	2.9×10^{-4}	1.2×10^{1}
Ru-106	$<3.0 \times 10^{-4}$	$<1.7 \times 10^{1}$
Tc-99	8.0×10^{-4}	3.4×10^{1}
Sr-90	1.8×10^{-3}	7.8×10^{1}

Uranium in bulk dust, weight %, sample basis: 2.32

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 67. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-247.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	4.3×10^{-5}	3.1
Pu-238	7.2×10^{-6}	5.2×10^{-1}
Np-237	1.9×10^{-5}	1.4
Th-234(1)	1.7×10^{-2}	1.2×10^{3}
Pa-234m	9.0×10^{-3}	6.5×10^{2}
Th-232	2.2×10^{-5}	1.6
Th-230	8.7×10^{-5}	6.3
Th-228	2.1×10^{-4}	1.5×10^{1}
Ra-228	2.7×10^{-5}	1.9
Ra-226	7.7×10^{-6}	5.5×10^{-1}
Cs-137	1.5×10^{-4}	1.1×10^{1}
Ru-106	$<2.0 \times 10^{-4}$	$<1.4 \times 10^{1}$
Tc-99	2.5×10^{-4}	1.8×10^{1}
Sr-90	1.3×10^{-3}	9.4×10^{1}

Uranium in bulk dust, weight %, sample basis: 1.39

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 68. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-248.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	5.9×10^{-6}	4.0×10^{-1}
Pu-238	1.5×10^{-6}	1.0×10^{-1}
Np-237	3.7×10^{-6}	2.5×10^{-1}
Th-234(1)	4.8×10^{-1}	3.3×10^{4}
Pa-234m	1.4×10^{-1}	9.5×10^{3}
Th-232	1.7×10^{-5}	1.2
Th-230	1.7×10^{-5}	1.2
Th-228	9.2×10^{-5}	6.3
Ra-228	2.2×10^{-6}	1.5×10^{-1}
Ra-226	2.0×10^{-6}	1.4×10^{-1}
Cs-137	8.2×10^{-5}	5.6
Ru-106	$<4.0 \times 10^{-4}$	$<2.7 \times 10^{1}$
Tc-99	3.4×10^{-5}	2.3
Sr-90	1.6×10^{-5}	1.1

Uranium in bulk dust, weight %, sample basis: 1.47

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 69. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-249.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	6.8×10^{-6}	1.5×10^{-2}
Pu-238	1.4×10^{-6}	3.0×10^{-3}
Np-237	7.0×10^{-6}	1.5×10^{-2}
Th-234(1)	4.1×10^{-1}	8.8×10^{2}
Pa-234m	2.5×10^{-1}	5.4×10^{2}
Th-232	3.4×10^{-5}	7.3×10^{-2}
Th-230	7.7×10^{-5}	1.7×10^{-1}
Th-228	3.3×10^{-5}	7.1×10^{-2}
Ra-228	3.3×10^{-6}	7.1×10^{-3}
Ra-226	2.4×10^{-6}	5.2×10^{-3}
Cs-137	2.5×10^{-5}	5.4×10^{-2}
Ru-106	$<3.3 \times 10^{-4}$	$<7.1 \times 10^{-1}$
Tc-99	2.1×10^{-4}	4.5×10^{-1}
Sr-90	5.5×10^{-4}	1.2

Uranium in bulk dust, weight %, sample basis: 46.59

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

TABLE 70. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-250.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	3.2×10^{-6}	9.3×10^{-3}
Pu-238	9.7×10^{-7}	2.8×10^{-3}
Np-237	6.2×10^{-6}	1.8×10^{-2}
Th-234(1)	4.0×10^{-1}	1.2×10^{3}
Pa-234m	2.3×10^{-1}	6.7×10^{2}
Th-232	3.6×10^{-5}	1.0×10^{-1}
Th-230	1.2×10^{-4}	3.5×10^{-1}
Th-228	7.2×10^{-5}	2.1×10^{-1}
Ra-228	2.0×10^{-6}	5.8×10^{-3}
Ra-226	4.9×10^{-6}	1.4×10^{-2}
Cs-137	1.4×10^{-5}	4.1×10^{-2}
Ru-106	$<2.0 \times 10^{-4}$	$<5.8 \times 10^{-1}$
Tc-99	5.7×10^{-5}	1.7×10^{-1}
Sr-90	1.3×10^{-4}	3.8×10^{-1}

Uranium in bulk dust, weight %, sample basis: 34.43

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

TABLE 71. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-251.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	3.3×10^{-5}	9.0×10^{-1}
Pu-238	3.1×10^{-6}	8.4×10^{-2}
Np-237	2.2×10^{-5}	6.0×10^{-1}
Th-234(1)	8.8×10^{-1}	2.4×10^{4}
Pa-234m	1.7×10^{-1}	4.6×10^{3}
Th-232	1.1×10^{-5}	3.0×10^{-1}
Th-230	2.2×10^{-4}	6.0
Th-228	5.1×10^{-5}	1.4
Ra-228	4.9×10^{-6}	1.3×10^{-1}
Ra-226	4.6×10^{-6}	1.3×10^{-1}
Cs-137	1.8×10^{-4}	4.9
Ru-106	$<4.0 \times 10^{-4}$	$<1.1 \times 10^{1}$
Tc-99	3.2×10^{-4}	8.7
Sr-90	1.5×10^{-4}	4.1

Uranium in bulk dust, weight %, sample basis: 3.68

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 72. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-253.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	8.9×10^{-6}	5.7×10^{-1}
Pu-238	9.5×10^{-7}	6.1×10^{-2}
Np-237	3.5×10^{-6}	2.2×10^{-1}
Th-234(1)	4.0×10^{-1}	2.5×10^{4}
Pa-234m	1.2×10^{-1}	7.6×10^{3}
Th-232	9.5×10^{-6}	6.1×10^{-1}
Th-230	3.6×10^{-5}	2.3
Th-228	4.2×10^{-6}	2.7×10^{-1}
Ra-228	2.8×10^{-6}	1.8×10^{-1}
Ra-226	1.8×10^{-6}	1.1×10^{-1}
Cs-137	1.6×10^{-4}	1.0×10^{1}
Ru-106	$<3.0 \times 10^{-4}$	$<1.9 \times 10^{1}$
Tc-99	2.0×10^{-5}	1.3
Sr-90	1.2×10^{-3}	7.6×10^{1}

Uranium in bulk dust, weight %, sample basis: 1.57

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 73. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-254.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.4×10^{-5}	6.5×10^{-1}
Pu-238	2.0×10^{-6}	9.3×10^{-2}
Np-237	7.2×10^{-6}	3.3×10^{-1}
Th-234(1)	4.1×10^{-1}	1.9×10^{4}
Pa-234m	2.0×10^{-1}	9.3×10^{3}
Th-232	1.7×10^{-5}	7.9×10^{-1}
Th-230	2.4×10^{-5}	1.1
Th-228	2.0×10^{-5}	9.3×10^{-1}
Ra-228	4.2×10^{-6}	1.9×10^{-1}
Ra-226	1.5×10^{-6}	6.9×10^{-2}
Cs-137	3.9×10^{-4}	1.8×10^{1}
Ru-106	$<3.0 \times 10^{-4}$	$<1.4 \times 10^{1}$
Tc-99	6.4×10^{-5}	3.0
Sr-90	1.7×10^{-3}	7.9×10^{1}

Uranium in bulk dust, weight %, sample basis: 2.16

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 74. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-256.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	3.2×10^{-5}	1.3
Pu-238	3.3×10^{-6}	1.3×10^{-1}
Np-237	1.3×10^{-5}	5.3×10^{-1}
Th-234(1)	4.2×10^{-1}	1.7×10^{4}
Pa-234m	1.9×10^{-1}	7.7×10^{3}
Th-232	2.4×10^{-5}	9.7×10^{-1}
Th-230	4.7×10^{-5}	1.9
Th-228	2.8×10^{-5}	1.1
Ra-228	5.1×10^{-6}	2.1×10^{-1}
Ra-226	3.2×10^{-6}	1.3×10^{-1}
Cs-137	5.2×10^{-4}	2.1×10^{1}
Ru-106	$<2.0 \times 10^{-4}$	<8.1
Tc-99	1.2×10^{-4}	4.9
Sr-90	1.1×10^{-4}	4.5

Uranium in bulk dust, weight %, sample basis: 2.47

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 75. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-260.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.5×10^{-5}	3.0×10^{-2}
Pu-238	5.3×10^{-6}	1.1×10^{-2}
Np-237	1.1×10^{-5}	1.5×10^{-2}
Th-234(1)	1.7×10^{1}	3.4×10^{4}
Pa-234m	6.7	1.4×10^{4}
Th-232	1.0×10^{-5}	2.0×10^{-2}
Th-230	1.3×10^{-4}	2.6×10^{-1}
Th-228	6.0×10^{-5}	1.2×10^{-1}
Ra-228	2.7×10^{-6}	5.4×10^{-3}
Ra-226	1.7×10^{-6}	3.4×10^{-3}
Cs-137	1.2×10^{-5}	2.4×10^{-2}
Ru-106	$<3.0 \times 10^{-3}$	<6.1
Tc-99	1.4×10^{-4}	2.8×10^{-1}
Sr-90	$<1.0 \times 10^{-5}$	$<2.0 \times 10^{-2}$

Uranium in bulk dust, weight %, sample basis: 49.47

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 76. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-261.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	2.5×10^{-5}	3.3×10^{-2}
Pu-238	2.8×10^{-6}	3.7×10^{-3}
Np-237	1.1×10^{-5}	1.5×10^{-2}
Th-234(1)	6.9	9.2×10^{3}
Pa-234m	2.8	3.7×10^{3}
Th-232	3.5×10^{-6}	4.7×10^{-3}
Th-230	5.2×10^{-5}	6.9×10^{-2}
Th-228	4.5×10^{-5}	6.0×10^{-2}
Ra-228	3.1×10^{-6}	4.1×10^{-3}
Ra-226	3.1×10^{-6}	4.1×10^{-3}
Cs-137	1.3×10^{-5}	1.7×10^{-2}
Ru-106(2)	$<2.0 \times 10^{-5}$	$<2.7 \times 10^{-2}$
Tc-99	2.1×10^{-4}	2.8×10^{-1}
Sr-90	1.0×10^{-5}	1.3×10^{-3}

Uranium in bulk dust, weight %, sample basis: 75.12

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

(2) Ru-106 determined by radiochemical analyses; all other radionuclides determined by gamma spectroscopy.

TABLE 77. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5-262.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.1×10^{-6}	1.0
Pu-238	1.1×10^{-6}	1.0
Np-237	4.3×10^{-6}	3.9
Th-234(1)	5.2×10^{-3}	4.7×10^{3}
Pa-234m	1.6×10^{-3}	1.5×10^{3}
Th-232	7.5×10^{-5}	6.8×10^{1}
Th-230	5.0×10^{-5}	4.5×10^{1}
Th-228	1.5×10^{-4}	1.4×10^{2}
Ra-228	1.8×10^{-6}	1.6
Ra-226	9.9×10^{-7}	9.0×10^{-1}
Cs-137	7.3×10^{-5}	6.6×10^{1}
Ru-106	$<3.0 \times 10^{-4}$	$<2.7 \times 10^{2}$
Tc-99	3.7×10^{-5}	3.4×10^{-1}
Sr-90	$<1.0 \times 10^{-5}$	<9.1

Uranium in bulk dust, weight %, sample basis: 0.11

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 78. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5A-100.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	8.9×10^{-6}	1.7×10^{-1}
Pu-238	3.2×10^{-6}	6.2×10^{-2}
Np-237	1.7×10^{-5}	3.3×10^{-1}
Th-234(1)	1.5×10^{-1}	2.9×10^{3}
Pa-234m	6.7×10^{-2}	1.3×10^{3}
Th-232	1.2×10^{-4}	2.3
Th-230	1.4×10^{-4}	2.7
Th-228	4.8×10^{-4}	9.3
Ra-228	6.2×10^{-6}	1.2×10^{-1}
Ra-226	3.0×10^{-6}	5.8×10^{-2}
Cs-137	1.6×10^{-4}	3.1
Ru-106	$<2.0 \times 10^{-4}$	<3.9
Tc-99	8.8×10^{-4}	1.7×10^{1}
Sr-90	$<1.0 \times 10^{-5}$	$<1.9 \times 10^{-1}$

Uranium in bulk dust, weight %, sample basis: 5.15

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 79. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR G5A-101.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	2.0×10^{-5}	3.2×10^{-1}
Pu-238	4.6×10^{-6}	7.4×10^{-2}
Np-237	1.5×10^{-5}	2.4×10^{-1}
Th-234(1)	1.5	2.4×10^{4}
Pa-234m	5.8×10^{-1}	9.4×10^{3}
Th-232	1.2×10^{-4}	1.9
Th-230	1.1×10^{-4}	1.8
Th-228	4.0×10^{-4}	6.5
Ra-228	7.1×10^{-6}	1.1×10^{-1}
Ra-226	3.3×10^{-6}	5.3×10^{-2}
Cs-137	2.6×10^{-4}	4.2
Ru-106	$<1.0 \times 10^{-3}$	$<1.6 \times 10^{1}$
Tc-99	8.0×10^{-5}	1.3
Sr-90	2.4×10^{-4}	3.9

Uranium in bulk dust, weight %, sample basis: 6.19

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 80. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 5 DUST COLLECTOR BLDG. 55.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	3.7×10^{-6}	1.8×10^{-1}
Pu-238	6.1×10^{-7}	2.9×10^{-2}
Np-237	5.3×10^{-6}	2.5×10^{-1}
Th-234(1)	4.9×10^{-1}	2.4×10^{4}
Pa-234m	1.9×10^{-1}	9.1×10^{3}
Th-232	5.7×10^{-5}	2.7
Th-230	8.4×10^{-5}	4.0
Th-228	1.1×10^{-4}	5.3
Ra-228	1.6×10^{-6}	7.7×10^{-2}
Ra-226	3.2×10^{-6}	1.5×10^{-1}
Cs-137	6.8×10^{-5}	3.3
Ru-106	$<2.0 \times 10^{-4}$	<9.6
Tc-99	1.0×10^{-4}	4.8
Sr-90	2.5×10^{-5}	1.2

Uranium in bulk dust, weight %, sample basis: 2.08

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 81. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 8 DUST COLLECTOR G43-27.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	5.1×10^{-4}	4.7
Pu-238	2.6×10^{-5}	2.4×10^{-1}
Np-237	7.0×10^{-5}	6.4×10^{-1}
Th-234(1)	2.8×10^{-2}	2.6×10^{2}
Pa-234m	2.6×10^{-2}	2.4×10^{2}
Th-232	1.2×10^{-4}	1.1
Th-230	1.1×10^{-2}	1.0×10^{2}
Th-228	1.8×10^{-4}	1.7
Ra-228	2.7×10^{-5}	2.5×10^{-1}
Ra-226	2.0×10^{-5}	1.8×10^{-1}
Cs-137	1.5×10^{-5}	1.4×10^{-1}
Ru-106	$<2.0 \times 10^{-4}$	<1.8
Tc-99	3.9×10^{-3}	3.6×10^{1}
Sr-90	2.8×10^{-5}	2.6×10^{-1}

Uranium in bulk dust, weight %, sample basis: 10.9

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 82. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 8 DUST COLLECTOR G43-29.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	4.4×10^{-4}	6.4×10^{-1}
Pu-238	5.7×10^{-5}	8.3×10^{-2}
Np-237	2.5×10^{-4}	3.6×10^{-1}
Th-234(1)	2.6×10^{-2}	3.8×10^{2}
Pa-234m	2.5×10^{-1}	3.6×10^{2}
Th-232	1.6×10^{-4}	2.3×10^{-1}
Th-230	1.3×10^{-3}	1.9
Th-228	5.6×10^{-4}	8.1×10^{-1}
Ra-228	2.4×10^{-5}	3.5×10^{-2}
Ra-226	2.5×10^{-5}	3.6×10^{-2}
Cs-137	1.5×10^{-4}	2.2×10^{-1}
Ru-106	$<2.0 \times 10^{-4}$	$<2.9 \times 10^{-1}$
Tc-99	2.2×10^{-2}	3.2×10^{1}
Sr-90	2.8×10^{-5}	4.1×10^{-2}

Uranium in bulk dust, weight %, sample basis: 68.87

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 83. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 8 DUST COLLECTOR 8035.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	8.6×10^{-5}	1.6×10^{-1}
Pu-238	2.0×10^{-5}	3.7×10^{-2}
Np-237	3.6×10^{-5}	6.7×10^{-2}
Th-234(1)	2.2×10^{-1}	4.1×10^{2}
Pa-234m	2.1×10^{-1}	3.9×10^{2}
Th-232	1.5×10^{-4}	2.8×10^{-1}
Th-230	3.2×10^{-4}	5.9×10^{-1}
Th-228	1.6×10^{-4}	3.0×10^{-1}
Ra-228	3.1×10^{-5}	5.8×10^{-2}
Ra-226	3.2×10^{-6}	5.9×10^{-3}
Cs-137	1.4×10^{-4}	2.6×10^{-1}
Ru-106	$<6.0 \times 10^{-4}$	<1.1
Tc-99	6.8×10^{-3}	1.3×10^{1}
Sr-90	1.5×10^{-5}	2.8×10^{-2}

Uranium in bulk dust, weight %, sample basis: 53.83

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 84. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT 9 DUST COLLECTOR G9N1-1039.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	9.3×10^{-4}	1.7
Pu-238	7.3×10^{-5}	1.3×10^{-1}
Np-237	2.5×10^{-4}	4.5×10^{-1}
Th-234(1)	7.6	1.4×10^{4}
Pa-234m	4.0×10^{-1}	7.2×10^{2}
Th-232	3.3×10^{-5}	5.9×10^{-2}
Th-230	1.5×10^{-4}	2.7×10^{-1}
Th-228	1.0×10^{-3}	1.8
Ra-228	7.0×10^{-6}	1.3×10^{-2}
Ra-226	2.4×10^{-4}	4.3×10^{-1}
Cs-137	4.0×10^{-4}	7.2×10^{-1}
Ru-106	$<5.0 \times 10^{-4}$	9.0×10^{-1}
Tc-99	3.8×10^{-2}	6.8×10^{1}
Sr-90	1.2×10^{-4}	2.1×10^{-1}

Uranium in bulk dust, weight %, sample basis: 54.84

Uranium compound: U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 85. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT P.P. DUST COLLECTOR G-1.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.7×10^{-6}	2.3×10^{-3}
Pu-238	1.7×10^{-6}	2.3×10^{-3}
Np-237	3.6×10^{-6}	4.8×10^{-3}
Th-234(1)	6.1×10^{-2}	8.1×10^{1}
Pa-234m	1.6×10^{-1}	2.1×10^{2}
Th-232	5.5×10^{-5}	7.3×10^{-2}
Th-230	2.6×10^{-4}	3.5×10^{-1}
Th-228	9.7×10^{-5}	1.3×10^{-1}
Ra-228	1.7×10^{-6}	2.3×10^{-3}
Ra-226	2.7×10^{-6}	3.6×10^{-3}
Cs-137	1.5×10^{-4}	2.0×10^{-1}
Ru-106	$<2.0 \times 10^{-4}$	$<2.7 \times 10^{-1}$
Tc-99	7.2×10^{-5}	9.6×10^{-2}
Sr-90	$<5.0 \times 10^{-6}$	$<6.6 \times 10^{-3}$

Uranium in bulk dust, weight %, sample basis: 75.24

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

TABLE 86. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT P.P. DUST COLLECTOR G-2.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.3×10^{-6}	1.7×10^{-3}
Pu-238	2.6×10^{-6}	3.5×10^{-3}
Np-237	7.4×10^{-6}	9.9×10^{-3}
Th-234(1)	9.2×10^{-2}	1.2×10^{2}
Pa-234m	1.8×10^{-1}	2.4×10^{2}
Th-232	8.5×10^{-5}	1.1×10^{-1}
Th-230	1.4×10^{-4}	1.9×10^{-1}
Th-228	1.0×10^{-4}	1.3×10^{-1}
Ra-228	2.1×10^{-6}	2.8×10^{-3}
Ra-226	1.4×10^{-6}	1.9×10^{-3}
Cs-137	1.6×10^{-4}	2.1×10^{-1}
Ru-106	$<1.0 \times 10^{-4}$	$<1.3 \times 10^{-1}$
Tc-99	1.3×10^{-4}	1.7×10^{-1}
Sr-90	$<4.0 \times 10^{-6}$	$<5.3 \times 10^{-3}$

Uranium in bulk dust, weight %, sample basis: 75.06

Uranium compound: UF_4

(1) Corrected to 12 noon on the day of sample collection.

TABLE 87. RADIONUCLIDES IN COLLECTOR BULK DUST.
PLANT P.P. DUST COLLECTOR 735-13-7050.

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION uCi/g SAMPLE	uCi/kgU
Pu-239+240	1.5×10^{-5}	6.2×10^{-1}
Pu-238	1.2×10^{-4}	4.9
Np-237	4.3×10^{-6}	1.8×10^{-1}
Th-234(1)	1.9×10^{-2}	7.8×10^{2}
Pa-234m	9.9×10^{-3}	4.1×10^{2}
Th-232	2.7×10^{-4}	1.1×10^{1}
Th-230	2.2×10^{-4}	9.1
Th-228	2.1×10^{-4}	8.6
Ra-228	1.6×10^{-4}	6.6
Ra-226	1.1×10^{-5}	4.5×10^{-1}
Cs-137	1.5×10^{-4}	6.17
Ru-106	$<2.0 \times 10^{-4}$	<8.2
Tc-99	5.0×10^{-5}	2.1
Sr-90	$<1.0 \times 10^{-5}$	4.1×10^{-1}

Uranium in bulk dust, weight %, sample basis: 2.43

Uranium compound: UO_3, U_3O_8

(1) Corrected to 12 noon on the day of sample collection.

TABLE 88. STACK AND SCRUBBER THORIUM DISCHARGES

Calendar Year	Discharge	Thorium Discharged kg
1955	Plant 9, dust collector(1)	159
1956	Plant 9, dust collector G42-615	10
1968	Plant 8, dust collector(1)	54
1968	Plant 8, scrubbers	141
1969	Plant 8, dust collector(1)	273
1970	Pilot Plant, dust collector(1)	26
1970	Plant 8, scrubbers	4
1973	Pilot Plant, dust collector(1)	10
	Total:	677 kg

(1) Records do not identify the specific dust collectors.

TABLE 89. FISCAL YEAR RECORD OF URANIUM IN WASTEWATER DISCHARGED TO THE GREAT MIAMI RIVER

FISCAL YEAR[1]	WASTEWATER DISCHARGE Kg U
1984	1054
1983	564
1982	755
1981	576
1980	685
1979	1175
1978	880
1977	965
1976A	179
1976	875
1975	1852
1974	1066
1973	1126
1972	1140
1971	1637
1970	1914
1969	2290
1968	1855
1967	2305
1966	3740
1965	3730
1964	10504
1963	4566
1962	3543
1961	5486
1960	4445
1959	6488
1958	3712
1957	2595
1956	1485
1955	657
1954	347
1953	106
1952	11
	74,308

(1) 1952 through 1976, the fiscal year is from July 1 through June 31 of the next year. 1976A is a three month transition period, July 1, 1976 through September 30, 1976. From 1977 to the present time, the fiscal year is from October 1 through September 30 of the next year.

TABLE 90. RADIONUCLIDES IN WASTEWATER DISCHARGES

CALENDAR YEAR	THORIUM kg	CURIES DISCHARGED								
		Sr-90	Tc-99	Ru-106	Cs-137	Ra-226	Ra-228	Np-237	Pu-238	Pu-239/240
1957	- (1)	-	-	-	0.5	-	-	-	-	
1958	-	-	-	-	-	0.5	-	-	-	-
1959	-	-	-	-	-	0.5	-	-	-	-
1960	-	-	-	-	-	0.5	-	-	-	-
1961	-	-	-	-	-	0.5	-	-	-	-
1962	-	-	-	-	-	0.5	-	-	-	-
1963	-	-	-	-	-	0.5	-	-	-	-
1964	-	-	-	-	-	0.5	-	-	-	-
1965	-	-	-	-	-	0.5	-	-	-	-
1966	-	-	-	-	-	0.5	-	-	-	-
1967	27	-	-	-	-	0.5	-	-	-	-
1968	128	-	-	-	-	0.5	1.1	-	-	-
1969	63	-	5.0	-	-	0.2	1.6	-	-	-
1970	29	-	2	-	-	0.2	0.5	-	-	-
1971	30	-	20	-	-	0.1	4×10^{-2}	-	-	-
1972	18	-	7.2	-	-	5.5×10^{-2}	1.5×10^{-2}	-	-	-
1973	9	-	6.2	-	-	2.4×10^{-2}	6×10^{-3}	-	-	-
1974	18	-	(2)	-	-	8×10^{-3}	6×10^{-3}	-	-	-
1975	6.4	-	(2)	-	-	1.3×10^{-2}	1.6×10^{-2}	-	-	-
1976	5.5	-	9	3×10^{-3}	2×10^{-2}	7×10^{-3}	8×10^{-3}	2×10^{-7}	4×10^{-7}	2×10^{-7}
1977	5.1	7.5×10^{-2}	0.1	8.2×10^{-3}	8.4×10^{-2}	7.2×10^{-3}	6.9×10^{-2}	$<5 \times 10^{-4}$	$<2.5 \times 10^{-5}$	$<5.6 \times 10^{-5}$
1978	5.5	6.9×10^{-3}	0.1	1.1×10^{-2}	1.5×10^{-2}	3.2×10^{-3}	4.3×10^{-3}	3.2×10^{-5}	$<2.4 \times 10^{-5}$	$<3.3 \times 10^{-5}$
1979	7.0	3.2×10^{-3}	3.4	1.8×10^{-3}	6.1×10^{-3}	7.8×10^{-4}	9.3×10^{-3}	1.9×10^{-4}	1.0×10^{-5}	2.9×10^{-5}
1980	2.1	2.6×10^{-3}	0.9	8.9×10^{-4}	1×10^{-2}	3.5×10^{-4}	3.3×10^{-3}	$<1 \times 10^{-4}$	3.8×10^{-6}	1.4×10^{-3}
1981	3.0	2.5×10^{-3}	4.2	6.7×10^{-4}	2.3×10^{-3}	1.1×10^{-2}	7×10^{-3}	$<1.4 \times 10^{-4}$	5.1×10^{-6}	2.9×10^{-5}
1982	3.8	3.2×10^{-3}	9.8	3.4×10^{-5}	2.8×10^{-3}	2.9×10^{-3}	1.2×10^{-2}	3×10^{-4}	4.9×10^{-6}	1.5×10^{-5}
1983	2.1	6.0×10^{-3}	21	3×10^{-4}	5.6×10^{-3}	1×10^{-3}	6×10^{-3}	$<2 \times 10^{-4}$	5×10^{-6}	8×10^{-5}
1984	4.5	1.2×10^{-2}	19	5×10^{-4}	1.7×10^{-2}	$<1.7 \times 10^{-2}$	$<1.4 \times 10^{-2}$	2×10^{-4}	3×10^{-5}	5×10^{-5}

(1) A dash indicates data were not collected

(2) Data were collected but could not be retreived.

TABLE 91. URANIUM IN OFF-SITE WELL WATER, 1984

WELL LOCATION (1)	NUMBER OF SAMPLES	AVERAGE CONCENTRATION pCi/L	% OF STANDARD (2)
1	12	0.34	0.03
2	9	0.27	0.02
3	10	0.34	0.03
4	10	1.29	0.11
5	11	1.42	0.12
6	12	1.29	0.11
7	11	0.95	0.08
8	12	0.54	0.05
9	12	0.81	0.07
10	12	0.34	0.03
11	7	0.68	0.06
12	11	165.19	13.77
13	12	0.41	0.03
14	12	0.74	0.06
15	12	219.35	18.28
16	11	0.41	0.03
17	11	36.29	3.02
18	11	0.34	0.03
19	12	0.20	0.02
20	10	0.20	0.02
21	12	0.27	0.02
22	9	0.74	0.06

(1) See Figure 5

(2) 1200 pCi/L, DOE Order 5480.1A, Attachment XI-1, Table II

TABLE 92. RADIATION DOSE FROM OFF-SITE WELL WATER USAGE

OFFSITE WELL	TARGET ORGAN	MILLIREM		% OF DOE GUIDE
		CALCULATED DOSE	DOE GUIDE	
No. 12	Bone Endosteum	908	1500	60.5
	Effective Dose	66.4	-	-
No. 15	Bone Endosteum	1204	1500	80.3
	Effective Dose	89	-	-
No. 17	Bone Endosteum	199	1500	13.3
	Effective Dose	14.6	-	-

TABLE 93. THORIUM AND RADIUM ISOTOPES IN REFINERY (PLANT 2/3) STACK DISCHARGES

CALENDAR YEAR	REFINERY FEED	MICROCURIES DISCHARGED				
		Th-232	Ra-228	Th-228	Th-230	Ra-226
1953	Pitchblende	0.16	0.90	22	5.5×10^3	4.2×10^3
1954	Pitchblende	1.9	10.8	265	6.6×10^4	5.0×10^4
1955	Pitchblende	1.9	10.8	265	6.6×10^4	5.0×10^4
1956	Canadian conc.	128	8.2	570	2.7×10^4	228
1957	Canadian conc.	549	35.3	2450	1.1×10^5	980
1958	Canadian conc.	123	7.9	550	2.6×10^4	220
1959	Canadian conc.	67	4.3	298	1.4×10^4	119
1960	Canadian conc.	119	7.7	532	2.5×10^4	213
1961	U.S. concentrates	2.0	2.4	168	7.8×10^3	67
1962	U.S. concentrates	2.0	2.4	168	7.8×10^3	67
1963	No operations	0	0	0	0	0
1964	No operations	0	0	0	0	0
1965	U.S. concentrates	0.38	0.46	32	1.5×10^3	13
1966	U.S. concentrates	1.6	1.9	135	6.3×10^3	54
1967	U.S. concentrates	0.80	0.96	67	3.1×10^3	27
1968	U.S. concentrates	0.28	0.34	24	1.1×10^3	9.5
1969	U.S. concentrates	0.25	0.30	20	9.6×10^2	8.2
1970	U.S. concentrates	1.4	1.7	117	5.5×10^3	47
1971	U.S. concentrates	0.78	0.94	65	3.0×10^3	26
1972	U.S. concentrates	12	14.8	1025	4.8×10^4	410
1973	U.S. concentrates	5.6	6.7	465	2.2×10^4	186
1974	U.S. concentrates	0.45	0.54	38	1.8×10^3	15
1975	U.S. concentrates	0.28	0.33	23	1.1×10^3	9.2
1976	U.S. concentrates	0.28	0.33	23	1.1×10^3	9.2
1977	U.S. concentrates	0.19	0.22	16	7.2×10^2	6.2

TABLE 94. POTENTIAL BOUNDARY DOSES FROM INHALATION PATHWAY

Radionuclide	Max. Avg. Concentration uCi/L(1)	50-Year Committed Dose, Rem		
		Lung	Bone Endosteum	Effective
Cs-137	9.00E-14	1.23E-08	3.83E-08	3.47E-08
Np-237	1.07E-14	6.78E-05	4.78E-04	3.39E-05
Pa-234	3.19E-11	1.34E-06	2.41E-08	2.61E-07
Pu-238	3.95E-15	2.58E-05	1.37E-04	1.44E-05
Pu-239,240	5.54E-14	3.58E-04	2.38E-03	2.34E-04
Ra-226	1.70E-13	1.61E-05	6.28E-06	2.32E-06
Ra-228	9.69E-15	1.01E-07	2.18E-07	2.80E-08
Rn-222(2)	6.70E-07	1.24E-02	5.38E-05	1.51E-03
Ru-106	1.00E-12	2.70E-05	6.42E-08	3.34E-06
Tc-99	8.70E-12	5.59E-05	1.89E-08	5.03E-07
Th-228	5.06E-14	3.26E-04	3.17E-04	5.12E-05
Th-230	7.46E-13	4.38E-03	3.09E-02	1.70E-03
Th-232	2.77E-14	1.44E-04	1.29E-03	6.67E-05
Th-234	3.19E-11	6.05E-05	1.50E-03	8.91E-06
U-234	6.64E-12	3.99E-02	2.56E-04	4.77E-03
U-235	2.18E-13	1.18E-03	7.04E-06	1.42E-04
U-236	4.49E-13	2.55E-03	1.59E-05	2.94E-04
U-238	6.30E-12	3.37E-02	2.01E-04	4.08E-03
Total dose from all radionuclides		9.51E-02	3.76E-02	1.29E-02
Percent of total dose:				
Uranium isotopes		81.3%	1.3%	72.0%
U, Th-230, Rn-222		99.0	83.5	96.9
U, Th-230, Rn-222, Th-232, Th-234, Pu-239/240		99.5	97.3	99.2

(1) Maximum average at the seven boundary sampling stations.
(2) Natural background of 3.0E-07 uCi/L has been subtracted.

Calculation of Radon Emission, Dispersion and Dosimetry from K65 Storage Tanks at the Feed Materials Production Center

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October 1985

Introduction

Two tanks containing residues principally resulting from the processing of pitchblend ore are located on the site of the Feed Materials Production Center near Fernald, Ohio. The residues contain high concentration of ^{226}Ra which produce copius amounts of the nobel gas ^{222}Rn. Release of this gas from the tanks is responsible for elevated concentration of ^{222}Rn in the atmosphere in the vicinity of the plant.

The objective of this study is to characterize the emission of radon from the tanks. This provides a source term which when coupled with meteorological data can be used to compute concentration of radon using an atmospheric dispersion model. The results of this model were used to assess population exposures and suggest ways for reducing concentration to values that are as low as reasonably achievable.

Materials and Methods

The emission of radon from tailings was computed using steady state diffusion equations. The effects of barometric pressure, wind speed and temperature were not included in the source term calculations.

The one dimensional steady state equations describing the diffusion of gases through porous media are (Co81)

$$\frac{D}{\varepsilon}\frac{d^2C}{dz^2} - \lambda C + \phi = 0$$

$$J = -D\frac{dC}{dz}$$

where;

C = Concentration of ^{222}Rn in pore system of the media

J = Current density (FLUX)

D = Effective diffusion coefficient in porous medium

ε = Porosity of medium = ratio of pore volume to bulk volume

λ = Decay constant of ^{222}Rn

ϕ = Production source term of ^{222}Rn in pores

$$= \frac{[Ra] * EF * \rho * \lambda}{\varepsilon} \qquad (pCi/cm^3)$$

[Ra] = Concentration of radium in medium (pCi/g)

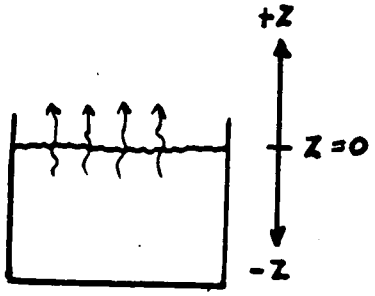
EF = Emanation fraction

ρ = Bulk density of medium

ℓ = Diffusion length = $\sqrt{D/\varepsilon\lambda}$

Solutions for these equations for special cases relating to the K65 tanks are as follows:

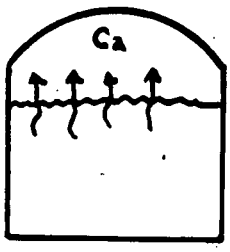
CASE I Open Tank



$$C(z) = \frac{\phi}{\lambda}\left(1-e^{z/\ell}\right)$$

$$J = \frac{\phi}{\lambda\ell} = \phi\varepsilon\ell$$

CASE II Closed Tank



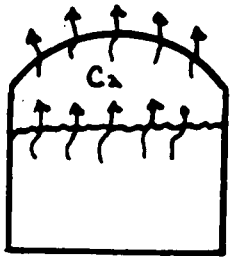
$$Ca = \frac{\phi}{\lambda}\left(\frac{\varepsilon\ell}{\varepsilon\ell+h}\right)$$

$\frac{\phi}{\lambda}$ = Radium Concentration in Pore Space

$\frac{\varepsilon\ell}{\varepsilon\ell+h}$ = Ratio of the value of air voids in the tailings to a depth of one diffusion length compared to the sum of this volume and the air space above tailings

h = Effective height of air volume above tailings

CASE III Diffusion from Tank Cover

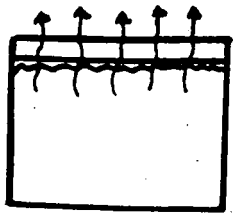


$$J = \varepsilon\lambda\ell\left\{\frac{Ca}{\sinh(L/\ell)}\right\}$$

Ca = Concentration of ^{222}Rn in Tank

L = Thickness of Concrete Cover

CASE IV Diffusion from Concrete Slab Directly Over Tailings



$$J_c = \phi \varepsilon_c \ell_c \left[\cosh\left(\frac{L}{\ell_c}\right) + \left(\frac{\varepsilon_t}{\varepsilon_c}\right)\left(\frac{\ell_t}{\ell_c}\right) \sinh\left(\frac{L}{\ell_c}\right)\right]^{-1}$$

Note: $\frac{J_c}{\phi \varepsilon \ell} = \frac{J_c}{J_o}$ = Ratio of Flux through Concrete Slab to Flux from Bare Tailings

The steady state emission rate can be obtained by multiplying the flux, J, by the surface area of the tanks. Since each tank is surrounded by an earthen beam, the radon was assumed to emerge from two flat surfaces having a diameter of 80′.

The dispersion of radon from the tanks was determined using the computer code UDAD (M079). This code was developed at Argonne National Laboratory for the Generic Environmental Impact Statement on Uranium Milling. It is particularly well suited for the dispersion of radon originating from mill tailings.

UDAD requires meteorological data including a stability wind rose which describes the relative frequency of occurrence for each wind direction, wind speed class and stability category. Unfortunately, this information does not exist specifically for the FMPC site near Fernald. However, data from the greater Cincinnati airport in Covington KY was available. Seasonal and annual wind distributions by Pasquill stability classes for the period 1/70 - 12/74 were obtained from the U. S. Department of Commerce, National Climatic Center (USDC81). This is the same meteorological data set that was used for the preparation of the Environmental Impact Statement for the FMPC.

The UDAD code provides the annual average concentration of radon gas (PCi/ℓ) and potential alpha energy from radon daughters (Working Level, WL). The principle risk from radon gas comes from the ingrowth and inhalation of radon daughters inside buildings. Thus, the dose conversion factor for population exposures was obtained using the following assumptions:

a) Outdoor radon eventually migrates indoors

b) Radon daughters reach an equilibrium ratio of 50%

c) People are resident in buildings for an average of 16 hours per day

d) The weighted dose equivalent conversion factor for inhalation of radon daughters in houses is 0.55 rem/WLM (OECD83)

This combination of assumptions yields a conversion factor of

$$0.1 \frac{\text{mrem/yr}}{\text{pCi/m}^3}$$

Population densities as a function of distance and direction from the site were obtained from the staff at FMPC.

Results

Source Term

The following parameters were used for modeling the K-65 tanks:

$[Ra] = 200 \text{ mCi/tonne} = 2 * 10^{5} \text{ pCi/g}$

$EF = 0.2$

$\rho = 1.94 * 10^{6} \text{ lbs} / 1.95 * 10^{5} \text{ f}^{3} = 1.6 \text{ g/cm}^{3}$

$\lambda = 2.1 * 10^{6} \text{ s}^{-1}$

ε tailings = 0.3

ε concrete = 0.3

ℓ concrete = 12 cm

ℓ tailings = 150 cm

Area of Tanks = 934m^{2}

637

NLO Case 1: Radon Flux from open tank

$$J_o = \phi \varepsilon \ell$$

$$= 20 \ (pCi/cm^2 \cdot s)$$

$$J_o = 2 * 10^5 \ (pCi/m^2 \cdot s)$$

NLO Case II: Concentration of radon above the tailings in a closed tank

The dome is simulated by a right circular cone of height 8' and diameter of 40'. The volume of a cone is $1/3\pi b^2 h$. Thus, the effective height of the dome is 8'/3 = 2.6'. The total effective height above the tailings is thus 10' = 300 cm.

$$Ca = 3 * 10^4 \ pCi/cm^3$$

$$= 3 * 10^7 \ pCi/\ell$$

NLO Case III: Radon Flux from Tank Covered with 4" (10 cm) of Concrete

$$J = 0.24 \ pCi/cm^2 \cdot s$$

$$= 2400 \ pCi/m^3 \cdot s$$

NLO Case IV: Radon Flux From 4" Concrete Slab Directly Above Tailings

$$J_c = J_o * 0.105$$

$$= 2 * 10^4 \text{ pCi/m}^2\text{·s}$$

The flux calculated from the model assuming a 4" concrete cover over the tanks is 2400 $pCi/m^2 \cdot s$. Measurements made by Monsanto Research Corporation ranged from 13 to $1.4 * 10^7$ $pCi/m^2 \cdot s$ (Ha85). The extremely large values were reported to be from cracks in the concrete dome. Using an average estimate of 2000 $pCi/m^2 \cdot s$ the annual emission rate is 60 Ci/yr. This source term was used as input for the dispersion code UDAD. Figure 1 shows the computed annual average contribution to the atmospheric radon from the K65 tanks. The data is presented as isopleths of 100, 10, 1 pCi/m^2.

The annual average background level near Cincinnati, Ohio has been estimated to be about 250 pCi/m^3 (Ge83). Measurements made by Monsanto Resesarch Corporation yield values similar to this at the fence line.

Conclusions

The dispersion model predicts that radon concentrations due to emissions from the K65 tanks fall to below background levels at distances less than 500 meters. The 100 pCi/m^2 isopleth lies entirely within the boundry of the FMPC facility. Fence line values are generally less than 5% of natural background.

The closest residence in the NNW direction (22.5°) is about 1.3 Km from the tanks. This corresponds to an excess radon concentration of 6 pCi/m^3 which yields an annual weighted dose equivalent of 0.6 mrem/year. The

closest residences at 90° and 180° would receive an annual weighted dose equivalent of 0.2 mrem/y and 0.3 mrem/y respectively.

An estimation of the population commitment is meaningless since the values predicted by the model are less than normal variation due to fluctuations in natural background and individual lifestyles.

The shape of the isopleths in this study do not conform to those presented in the Monsanto study (Ha85). This should not be surprising since the code cannot model the turbulence and shadowing due to structures very close to the source term and measurements were made only during a few months spanning late autumn and winter. This illustrates the considerable uncertainty in such modeling exercises.

In order to validate the conclusions of this study a comprehensive monitoring program should continue for at least one calendar year. A continuous radon monitor based on a flow through scintillation flask would provide information at daily intervals which could be integrated to yield an annual average. The daily variations could be compared to wind speed and direction to improve the predictive capabilities of the model.

Outdoor measurements of working levels are difficult because of the plate-out characteristics of radon daughters. Since the risk is related to ingrowth and inhalation of daughters indoors it is suggested to make continuous measurements in a small building or trailer. Commercial continuous working level monitors adequately measure radon daughters under these conditions.

A monitoring station containing a continuous radon and working level monitor should be located in a northeast direction about 500 meters from the tank and at the fence line. Background measurements in a general upwind

direction could be made with integrating devices if another set of continuous monitor is not available.

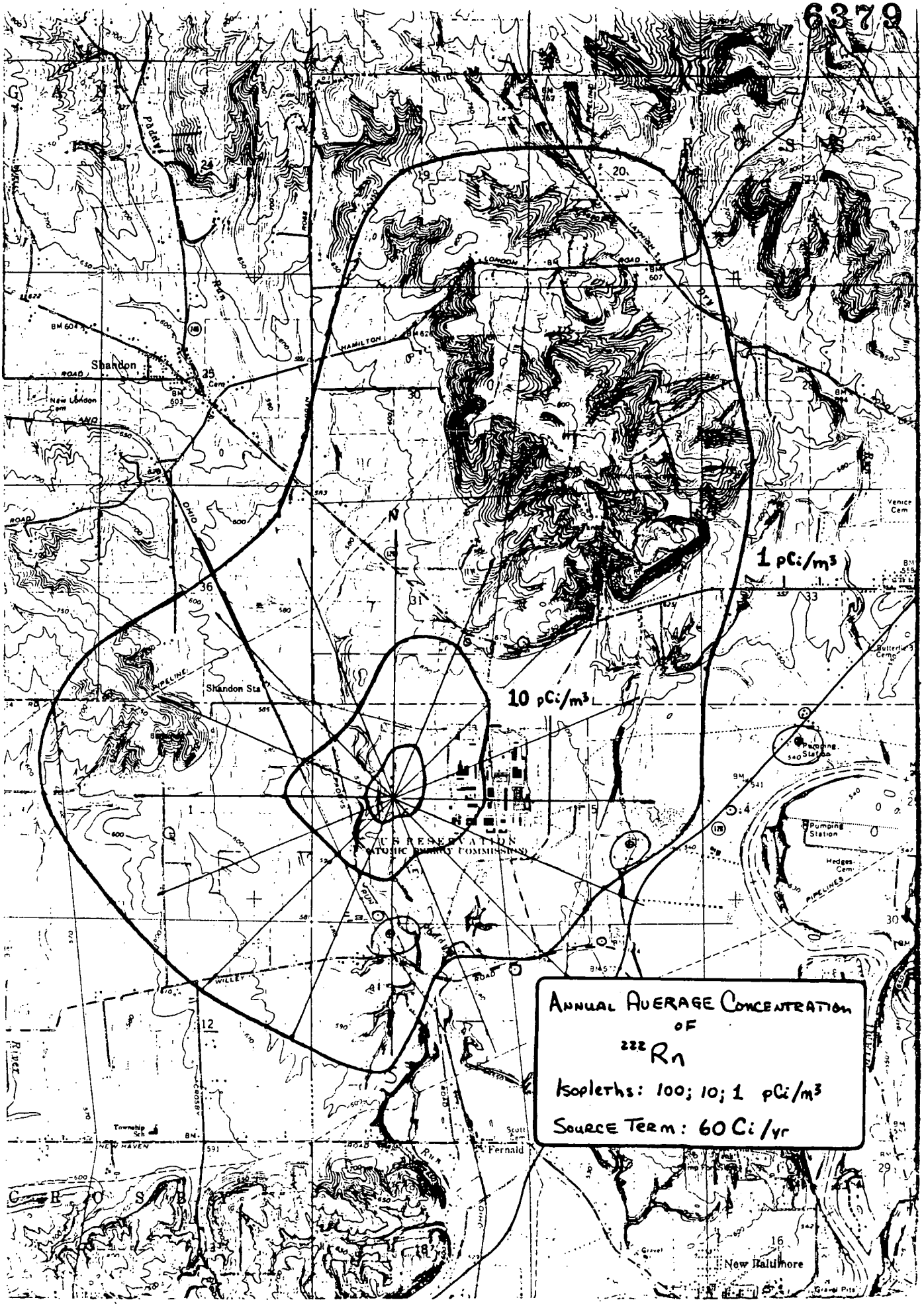
Several continuous monitors are available at Argonne National Laboratory. Since FMPC is a DOE facility a loan arrangement could be negotiated for the duration of the experiment.

If measurements indicate radon concentrations larger than predicted by the model several steps could be taken to reduce emissions from the tank. These are as follows:

a) Seal the apparent cracks in the dome. This is useful but could turn out to be a never ending exercise.

b) Increase the thickness of the concrete cover. This would certainly help but an additional 4" of concrete would only reduce the average flux by 60%.

c) Keep the tailings covered with water. This is an extremely efficient barrier since 2 cm of water is equivalent to 12 cm of concrete. However, caution should be exercised to prevent leaching and migration of Ra into underground aquafers.


1 pCi/m³
10 pCi/m³
Shandon
Shandon Sta
Fernald
New Baltimore
U.S. RESERVATION
ATOMIC ENERGY COMMISSION
ANNUAL AVERAGE CONCENTRATION
OF
²²²Rn
Isopleths: 100; 10; 1 pCi/m³
Source Term: 60 Ci/yr

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